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FRUIT AND VEGETABLE PROCESSING AND FOOD TECHNOLOGY: A SUMMARY OF RESEARCH

OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER
U. S. 250 and OHIO 83 SOUTH
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EVALUATION OF TOMATO CULTIVARS FOR PROCESSING

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The objective of this study was to determine the suitability of 23 Ohio-grown tomato cultivars for processing and the quality of the canned products. The cultivars included in the study were classified as established and/or new cultivars to Ohio tomato growers.

Methods

The 1974 processing tomato project included 13 cultivars grown in replicated plots under acceptable commercial practices at the OARDC Northwestern Branch near Hoytville. Each cultivar was machine harvested (with FMC Western model), with little or no sort on the harvester, and bulk handled.

Following harvest the tomatoes were transported by truck to the pilot specific gravity separator at Leipsic and the usable fruit were further transported (approximately 100 miles) to the Food Processing Pilot Plant at The Ohio State University, Columbus, for processing. All lots were processed after 24 hours hold following harvest as peeled whole tomatoes.

The other 10 cultivars were grown at The Ohio State University farms, Columbus. These tomatoes were hand harvested and then transported to the Food Processing Pilot Plant for processing as peeled whole tomatoes.

Procedure

Twenty field-run tomatoes were selected and used for objective and subjective quality evaluation.

Size was determined by weighing the sample and then calculating for a 25-lb. sample. In addition, the tomatoes were subjectively classed for shape, fruit surface, core, firmness, and type of defects.

Stem scar length, stylar scar length, stem length, and wall thickness were determined by measuring the average length in inches.

Percent red color was determined by counting the number of tomatoes in the sample which had full red color.

Cut surface color was determined on an Agtron E-5 instrument after making a crosswise cut in the tomato and reading the values after standardizing the instrument at 48.

The sample was then quartered, extracted in a Food Processing Equipment Co. Laboratory pulper, and de-aerated.

The sample was evaluated for color with the Hunter Color and Color Difference Meter, using the wide area illuminator and large aperture. The instrument was standardized with the "Red" tile with L=29.59, aL=27.40, bL=12.54.

The pulp was presented to the Agtron E-5 instrument in a standard plastic sample cup with the instrument calibrated at 48. The color reading was taken directly and recorded as such.

An Abbe refractometer was used for direct determinations of percent soluble solids on raw and canned juice. The instrument was standardized with distilled water and all readings were converted to 20° C.

The pH was determined by the glass electrode method (Beckman Zeromatic pH meter), using 10 ml. of tomato juice (raw or canned) diluted with 90 ml. of distilled water.

Percent total acid as citric was determined as follows. The sample used for pH determination was directly titrated using 0.1 normal sodium hydroxide solution to a pH of 8.1. Calculations using the following equation were made:

$$\text{Percent acid} = \frac{(\text{No. of ml. of 0.1N NaOH})\ (.0064)\ \text{X}\ 100}{10\ \text{ml. sample}}$$

To determine ascorbic acid, 10 ml. aliquots of tomato juice were diluted with 90 ml. of 1% meta phosphoric acid and filtered. A 10-ml. aliquot of the filtrate was titrated with 0.2% 2,6-dichloro-phenolindophenol indicator solution. Milligrams of Vitamin C were determined by the following formula:

$$\text{Dye factor x ml. of dye x 100} = \frac{\text{mg. Vit. C}}{\text{100 g.}}$$

Preparation and processing: All tomatoes were prepared for canning by washing, lye peeling (18% caustic soda and Faspeel at 190° F. for 20 seconds), and processed as whole tomatoes. Each lot of whole tomatoes was filled to 10.5-11.0 oz. in No. 303 fruit enamel tin cans with a 50-grain salt tablet containing 44-1/2% NaCl, 15% $CaSO_4 \cdot H_2 0$, 37% citric acid, and 3.5% Na bicarbonate.

Grades of canned tomatoes: Grades were determined in accordance with the U. S. standards for grades of canned tomatoes.

The results are presented in Tables 1 and 2.

Summary

Ohio State University Cultivars

Chico III	Pear. Above average canned quality, but high pH and low total acid value; must be acidified; does not need coring.
C-28	High in percent total acid and vitamin C content; average quality; some blossom end rot and gray areas in end product.
Heinz 1350	Large fruit high in percent total acid; good quality.
Lafayette	Very small fruit; does not need coring; above average quality.
Heinz 1409	Large fruit; above average quality.
Heinz 1439	Large fruit; average quality, although color inferior to other cultivars.

Vermillion	Average quality; high in vitamin C content and percent total acid; good raw product color.
C. S. 309	Large fruit; above average quality.
C. S. 290	Small fruit, but average quality; good color.
Chico Grande	Very small fruit; good color; above average quality.

Northwestern Branch Cultivars

OX 735	Medium core; 60% defects, dry crack with mold; good flavor; firm canned tomato; above average quality.
OX 739	Medium to large core; not well colored; must be cored.
OX 738	Fruit soft with average canned quality.
OX 731	Good color; high percent total acid; very good canning quality.
OX 7310	Excessive defects (long cracks, stems, anthracnose); average canned quality.
OX 736	Best of cultivars for canned quality.
OHIO 1970	Largest fruit of all cultivars in 1974; excessive defects with long and radial scars, streaks; average canned tomato color.
OX 737	Excessive defects (radial cracks and radial scars); small core; above average quality.
OHIO 2070	Large fruit and above average canned quality.
OX 733	Poor processed product color.
Chico III	Poor. Low total acid, must be acidified; need not be cored. Excellent canned quality.
Castle 220	Pear. Small core; must be acidified; excellent canned quality.
Castle 336	Pear. Small core; must be acidified; excellent canned quality.

TABLE 1.--Raw and Processed Tomato Quality Evaluation, OSU, 1974.

	Chico III	C-28	Heinz 1350	Lafayette	Heinz 1409
Raw					
Fruit Shape	Pear	Globe	Globe	Globe	Globe
Fruit Surface	Smooth	Smooth	Smooth	Smooth	Smooth
Fruit Size	Small	Variable	Medium	Small	Medium
Diameter (in.)	1 1/2-2	1 1/2-3	1 3/4	2	2 1/2
Length	2 1/4	2-2 1/2	2	1 1/2	2
Ct./25 lb.	200	150	108	212	108
Stem Scar (in.)	1/4	1/4	3/8	1/4	3/8
Stylar Scar (in.)	None	3/8	1/8	None	1/4
Stem Length (in.)	1/2	1/2	1/2	----	1/2
Firmness	Hard	Medium	Medium	Hard	M-S
No. Locules	3	6	6	4	5
Wall Thickness (in.)	3/16	1/4	1/2	1/4	1/4
Core	None	None	None	----	None
Type of Defects	None	----	----	----	----
E-5 Surface	34	35	42.5	50	45.8
Percent Red Color	----	----	----	----	----
TCM	80.2	67.7	58.5	57.9	57.6
E-5 Pulp Color	23	31	50	55.5	50.5
Hunter L	23.3	27.5	31.2	32.5	31.9
a	26.7	32	28.2	30.6	29.2
b	9	11	11.2	10.9	12.1
a/b	2.77	2.9	2.52	2.8	2.41
pH	4.5	4.3	4.3	4.2	4.3
Percent TA as Citric	.364	.5	.51	.46	.524
Percent SS	5.8	6.1	5.4	5.0	5.6
Vit. C. mg./100 mg.	19.8	26.4	18.0	13.5	16.65
Canned					
Drained Wt. (20)	17	17	17	16	19
Wholeness (20)	20	18.5	18.5	20	19.25
Color (30)	30	27	28	29	27
Defects (30)	30	27.5	30	30	30
Total (100)	97	90	93.5	95	95.25
Grade	A	A	A	A	A
pH	4.2	4.1	4.2	4.25	4.2
Percent TA as Citric	.48	.59	.55	.59	.60
Percent SS	6.2	6.3	6.8	6.7	6.5
Cored	No	Yes	Yes	No	Yes
Flavor, Odor	----	----	----	----	----
Comments:		Dark gray areas		Small, firm	

TABLE 1 (Continued).--Raw and Processed Tomato Quality Evaluation, OSU, 1974

	Heinz 1439	Vermillion	CS 309	CS 290	Chico Grande
Raw					
Fruit Shape	Globe	Globe	Globe	Globe	Pear
Fruit Surface	Smooth	Smooth	Smooth	Smooth	Smooth
Fruit Size	Medium	Small	Medium	Small	Small
Diameter (in.)	2 1/2	2	2	1 3/4	1 1/2
Length (in.)	2 1/2	1 3/4	2 1/2	1 3/4	2
Ct./25 lb.	116	132	110	178	232
Stem Scar (in.)	1/4	None	3/8	1/4	1/4
Stylar Scar (in.)	1/8	None	None	None	None
Stem Length (in.)	1/2	1/2	1/2	1/4	1/2
Firmness	Hard	M-S	Hard	Hard	Hard
No. Locules	4	5	4	3-4	3
Wall Thickness (in.)	1/4	1/2	1/4	3/8	1/4
Core	None	None	None	None	None
Type of Defects	None	----	None	None	None
E-5 Surface	44.4	30.0	44.9	45	45
Percent Red Color	----	----	----	----	----
TCM	54.6	73.4	67.8	82.7	71.3
E-5 Pulp Color	58	41	40	41	42
Hunter L	32.2	26.2	27.7	23.8	26.3
a	29.5	31.3	29.1	27.1	29.5
b	12.8	10.3	10.4	8.9	11.1
a/b	2.3	3.04	2.8	3.04	2.66
pH	4.35	4.3	4.35	4.4	4.3
Percent TA as Citric	.454	.524	.454	.403	.396
Percent SS	4.2	4.4	4.3	3.8	5.3
Vit. C. mg./100 mg.	16.65	20.7	17.55	11.25	15.3
Canned					
Drained Wt. (20)	20	18	20	15	17
Wholeness (20)	18	18.5	18.3	20	18.5
Color (30)	26*	27.75	28	30	29.5
Defects (30)	30	30	30	30	30
Total (100)	94	95.15	96.3	95	95
Grade	B	A	A	A	A
pH	4.2	4.5	4.2	4.3	4.2
Percent TA as Citric	.58	.58	.59	.52	.56
Percent SS	5.9	6.2	6.0	6.2	6.7
Cored	Yes	Yes	Yes	---	Yes
Flavor, Odor	---	---	---	---	---
Comments:			Large		

TABLE 2.--Raw and Processed Tomato Quality Evaluation, OARDC Northwestern Branch, 1974.

	OX 735	OX 739	OX 738	OX 731
Raw				
Fruit Shape	Globe	Globe	Globe	Globe
Fruit Surface	Smooth	Smooth	Smooth	Smooth
Fruit Size	Medium	Small	Medium	Medium
Diameter (in.)	2 1/4	2 1/4	2 1/2	2
Length (in.)	2	2	2	2 1/4
Ct./25 lb.	108	121	111	138
Stem Scar (in.)	3/8	3/8	Variable	1/4
Stylar Scar (in.)	None	3/8	Variable	None
Stem Length (in.)	1/2	1 1/2	1/2	1/4
Firmness	Soft	Variable	Soft	Medium
No. Locules	5	6	5	4
Wall Thickness (in.)	1/4	1/8	1/4	1/4
Core	Medium	M-L	Medium	Medium
Type of Defects	60%	20%	30%	30%
E-5 Surface	----	----	----	----
Percent Red Color	80	50	100	90
TCM	70.3	59.8	69.5	67.8
E-5 Pulp Color	31	47	32	41
Hunter L	29.9	29.7	27.6	27.5
a	39	30.3	32	31.8
b	13.1	12.9	11.8	11.9
a/b	2.98	2.35	2.71	2.67
pH	4.08	4.05	4.0	4.05
Percent TA as Citric	.39	.43	.48	.56
Percent SS	4.9	4.8	4.0	4.4
Vit. C mg /100 mg.	10.26	9.12	11.97	10.26
Canned				
Drained Wt. (20)	20	20	20	20
Wholeness (20)	20	19.25	17.5	20
Color (30)	27	22*	25.2*	28.5
Defects (30)	30	27	27.5	29.25
Total (100)	96	88.25	90.2	97.8
Grade	A	C	B	A
pH	4.2	4.15	4.2	4.2
Percent TA as Citric	.48	.49	.48	.66
Percent SS	5.45	5.3	5.3	5.8
Cored	Yes	No	No	No
Flavor, Odor	Good	Good	----	Good
Comments:	Firm	Should be cored		Good

TABLE 2. (Continued).--Raw and Processed Tomato Quality Evaluation, OARDC Northwestern Branch, 1974.

	OX 7310	OX 736	OHIO 1970	OX 737
Raw				
Fruit Shape	Globe	Globe	Globe	Globe
Fruit Surface	Smooth	Smooth	S-SS	Smooth
Fruit Size	Medium	Medium	Medium	Medium
Diameter (in.)	2 1/2	2 1/2	2 3/4	2 1/2
Length (in.)	2	2 1/4	2 1/2	2
Ct./25 lb.	104	108	86.2	119
Stem Scar (in.)	3/8	Variable	3/8	3/8
Stylar Scar (in.)	Variable	None	3/8	None
Stem Length (in.)	1/4	1/4	1/4	1/4
Firmness	Soft	Soft	Soft	Soft
No. Locules	6	5	7	5
Wall Thickness (in.)	1/8	1/4	1/4	1/4
Core	Medium	Medium	M-L	Small
Type of Defects	70%	30%	60%	60%
E-5 Surface	----	----	----	----
Percent Red Color	40	80	70	100
TCM	63.6	65.6	68.2	71.4
E-5 Pulp Color	35	33	33	40
Hunter L	28.6	28.9	27.5	26.5
a	31.9	36.0	32.6	32.2
b	12.6	13.2	11.6	11.6
a/b	2.53	2.72	2.81	2.77
pH	4.12	4.0	4.1	4.0
Percent TA as Citric	.35	.42	.45	.39
Percent SS	4.6	4.5	4.2	3.9
Vit. C mg./100 mg.	10.26	14.82	8.55	13.21
Canned				
Drained Wt. (20)	20	19	19	20
Wholeness (20)	19.25	20	16.75	18.5
Color (30)	25*	29	24.25*	27
Defects (30)	28	30	30	30
Total (100)	92.25	98	90	95.5
Grade	B	A	B	A
pH	4.2	4.2	4.1	4.2
Percent TA as Citric	.63	.45	.52	.47
Percent SS	5.4	5.5	5.6	4.9
Cored	No	Yes	Yes	Yes
Flavor, Odor	Good	Good	Good	----
Comments:	Firm; should be cored	Firm	Streaks	

TABLE 2 (Continued).--Raw and Processed Tomato Quality Evaluation, OARDC Northwestern Branch, 1974.

	Ohio 2070	OX 733	Chico III	Castle 220	Castle 336
Raw					
Fruit Shape	Globe	Globe	Pear	Pear	Pear
Fruit Surface	S-SS	Smooth	Smooth	Smooth	Smooth
Fruit Size	M-L	Medium	Small	Medium	Medium
Diameter (in.)	2 1/2	2 1/4	1 1/2	1 1/2	1 3/4
Length (in.)	2 1/4	2 1/4	2 3/4	3 3/4	3
Ct./25 lb.	96.2	167	192	147	156
Stem Scar (in.)	Variable	1/4	1/4	1/4	1/4
Stylar Scar (in.)	Variable	None	None	None	None
Stem Length (in.)	1/2	1/4	----	----	----
Firmness	Soft	Soft	Soft	Medium	Medium
No. Locules	5	2-3	2-3	2-3	3
Wall Thickness (in.)	1/8	1/8	3/8	3/8	1/4
Core	Medium	Medium	S-M	Small	Medium
Type of Defects	40%	50%	20%	20%	20%
E-5 Surface	----	----	----	----	----
Percent Red Color	100	80	100	80	100
TCM	66.7	59.4	64.6	72.3	58
E-5 Pulp Color	31	47	32	28	41
Hunter L	28.2	30.0	28.6	26.6	30.5
a	36.3	29.3	33.0	35.5	29.9
b	12.3	13.3	12.5	12.6	13.2
a/b	2.95	2.2	2.64	2.81	2.26
pH	4.0	4.0	4.1	4.15	4.12
Percent TA as Citric	.49	.44	.33	.33	.34
Percent SS	4.6	4.8	4.7	4.4	4.2
Vit. C mg./100 mg.	11.97	12.54	13.11	11.97	9.69
Canned					
Drained Wt. (20)	20	20	20	20	20
Wholeness (20)	19.25	18	19.75	20	20
Color (30)	27	21*	28	30	30
Defects (30)	30	30	30	30	30
Total (100)	96.75	89.0	97.75	100	100
Grade	A	C	A	A	A
pH	4.2	4.15	4.25	4.2	4.2
Percent TA as Citric	.60	.60	.44	.46	.52
Percent SS	5.6	5.3	5.5	5.4	5.0
Cored	Yes	No	No	----	----
Flavor, Odor	Good	----	Good	----	----
Comments:	Firm; streaks		Good flavor		

PHYSICAL AND SUBJECTIVE COLOR EVALUATION OF TOMATO JUICE

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Seventy-five samples of tomato juice were collected from Oct. 1 to Nov. 30, 1973, from supermarkets in the Columbus, Ohio, area. The samples of tomato juice were evaluated for color visually (subjectively) and physically (objectively). Visual examination was made with the MacBeth-Munsell Disc Colorimeter to obtain the U.S.D.A. Color Score. Instruments and methods used to physically evaluate the tomato juice color were the Hunter D-6 Tomato Colorimeter (Tomato Color Index), Hunter D25 Color and Color Difference Meter (Lb_L/a_L, a_L/b_L), Agtron M-400-A (blue, green, and red modes), Agtron Model F, and Agtron E-5.

Statistical analysis using correlation coefficients, coefficients of determination, and regression lines were used to compare instrumental methods to the U.S.D.A. Color Score and for comparing the instruments and methods among themselves.

The following conclusions were drawn from this study:

1. The instrumental methods which correlated with U.S.D.A. Color Score for purposes of prediction were Hunter D-6 Tomato Colorimeter, Hunter Lb_L/a_L. Hunter a_L/b_L, Agtron M-400-A (green mode), Agtron Model F, and Agtron E-5 (Table 1).

2. The Hunter D-6 Tomato Colorimeter (Tomato Color Index) gave the highest correlation to U.S.D.A. Color Score for tomato juice (Figure 1).

3. Hunter Lb_L/a_L is a reliable indication of the color of tomato juice (Figure 2).

4. Hunter Lb_L/a_L is preferred over Hunter a_L/b_L for determination of U.S.D.A Color Score of tomato juice with the Hunter D25 Color and Color Difference Meter (Table 1).

5. Agtron M-400-A gave significant results for tomato juice color evaluation only at the green mode (546 nm.).

6. A correlation coefficient of -0.813 was found between Agtron E-5 reflectance and the Tomato Color Index, the two most common methods used for tomato juice color evaluation (Table 2 and Figure 3).

7. Minimum values for U.S.D.A. Grades A and C for tomato juice color were calculated and are shown in Table 3.

References

1. Beck, Kenneth L. 1974. Physical and Subjective Color Evaluation of Tomato Juice. M. S. Thesis, The Ohio State University.

2. Beck, Kenneth L. Feb. 1974. Objective Evaluation of Commercial Tomato Juice. OARDC, 1974 Research Progress Reports, Hort. Mimeo Series 403, pp. 12-13.

TABLE 1.--Correlation Coefficients and Coefficients of Determination for U.S.D.A. Color Score with Instruments and Methods used for Tomato Juice Color Measurement.

Instruments and Methods	Coefficient of Correlation "r"	Determination "r^2" (percent)	Significance
U.S.D.A. Color Score vs. Hunter D-6 Tomato Colorimeter	0.881	77.62	.01
U.S.D.A. Color Score vs. Hunter Lb_L/a_L	-0.871	75.86	.01
U.S.D.A. Color Score vs. Hunter a_L/b_L	0.850	72.25	.01
U.S.D.A. Color Score vs. M-400-A (Green Mode)	-0.830	68.89	.01
U.S.D.A. Color Score vs. Agtron Model F	-0.801	64.16	.01
U.S.D.A. Color Score vs. Agtron E-5	-0.782	61.15	.01

TABLE 2.--Correlation Coefficients and Coefficients of Determination for the Instrumental Methods Used for Tomato Juice Color Measurement.

Instrument and Methods	Coefficient of Correlation "r"	Determination "r^2" (percent)	Significance
Hunter D-6 Tomato Colorimeter vs. Agtron M-400-A (Green Mode)	-0.892	79.57	.01
Agtron E-5 vs. Hunter D-6 Tomato Colorimeter	-0.813	66.10	.01
Agtron Model F vs. Hunter D-6 Tomato Colorimeter	-0.867	75.17	.01
Agtron E-5 vs. Hunter a_L/b_L	-0.855	73.10	.01
Hunter a_L/b_L vs. Agtron M-400-A (Green Mode)	-0.812	65.93	.01
Agtron E-5 vs. Hunter Lb_L/a_L	0.853	72.76	.01
Agtron E-5 vs. Agtron M-400-A (Green Mode)	0.795	63.20	.01
Agtron Model F vs. Agtron M-400-A (Green Mode)	0.961	92.35	.01

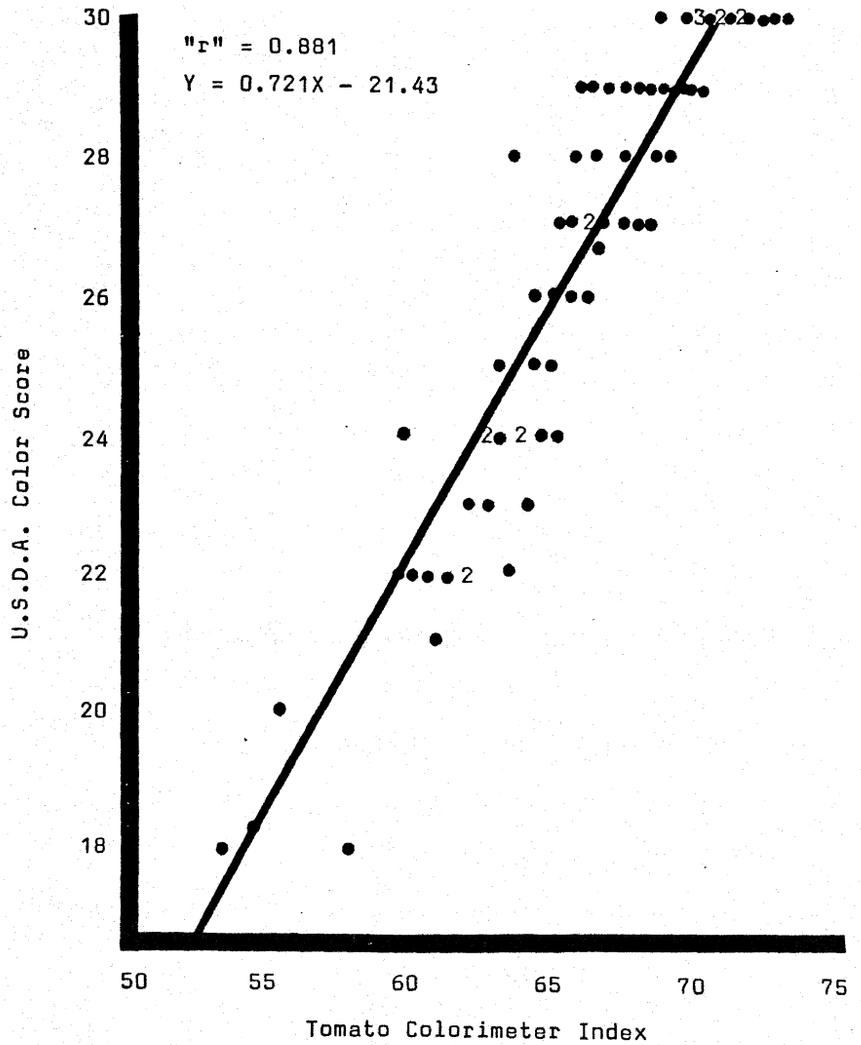

FIG. 1.--Correlation Coefficient and Regression Line Comparing U.S.D.A. Color Score and Hunter D-6 Tomato Colorimeter for Tomato Juice Color.

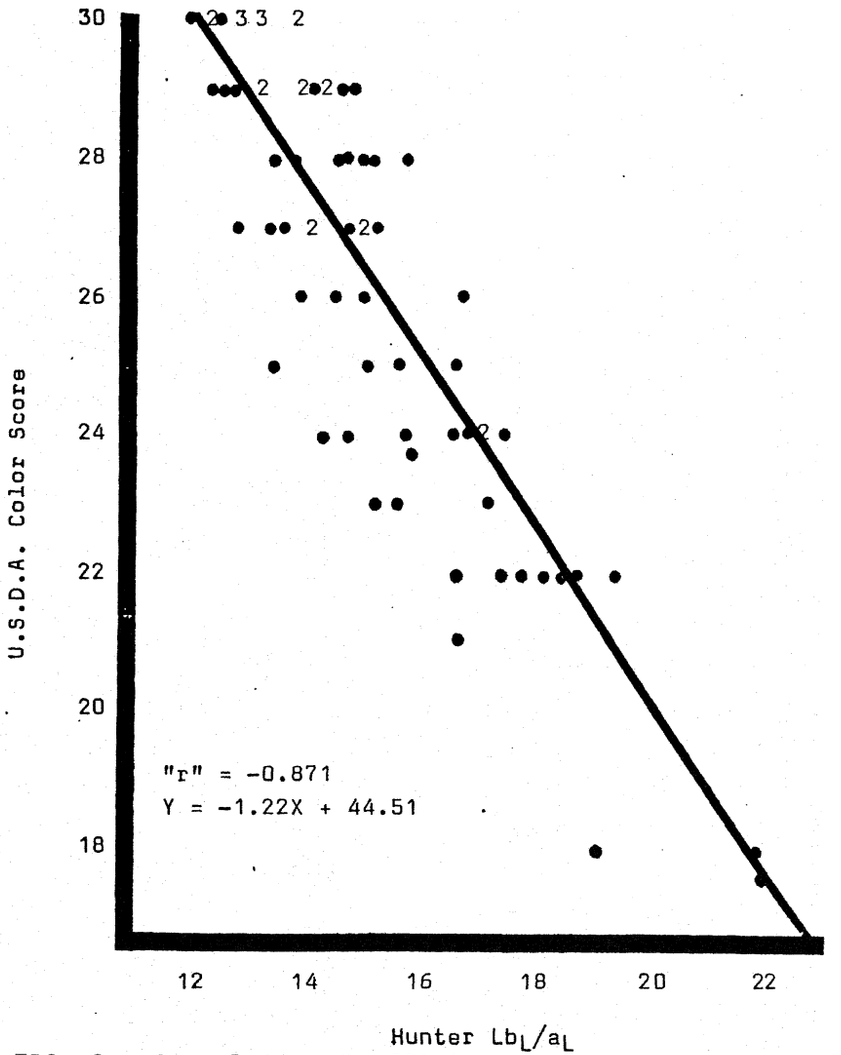

FIG. 2.--Correlation Coefficient and Regression Line Comparing U.S.D.A. Color Score and Hunter Lb_L/a_L for Tomato Juice Color.

TABLE 3.--Minimum Suggested Values for U.S.D.A. Grades A and C for Tomato Juice Color Using Objective Color Instruments.

Instrument	U.S.D.A. Grade A (26 pts.)	U.S.D.A. Grade C (22 pts.)
Hunter D-6 Tomato Colorimeter	65.18	61.6
Hunter Lb_L/a_L	15.17	17.63
Hunter a_L/b_L	1.76	1.54
Agtron M-400-A (Green Mode)	45.6	53.2
Agtron Model F	41.7	49.2
Agtron E-5	36.1	46.9

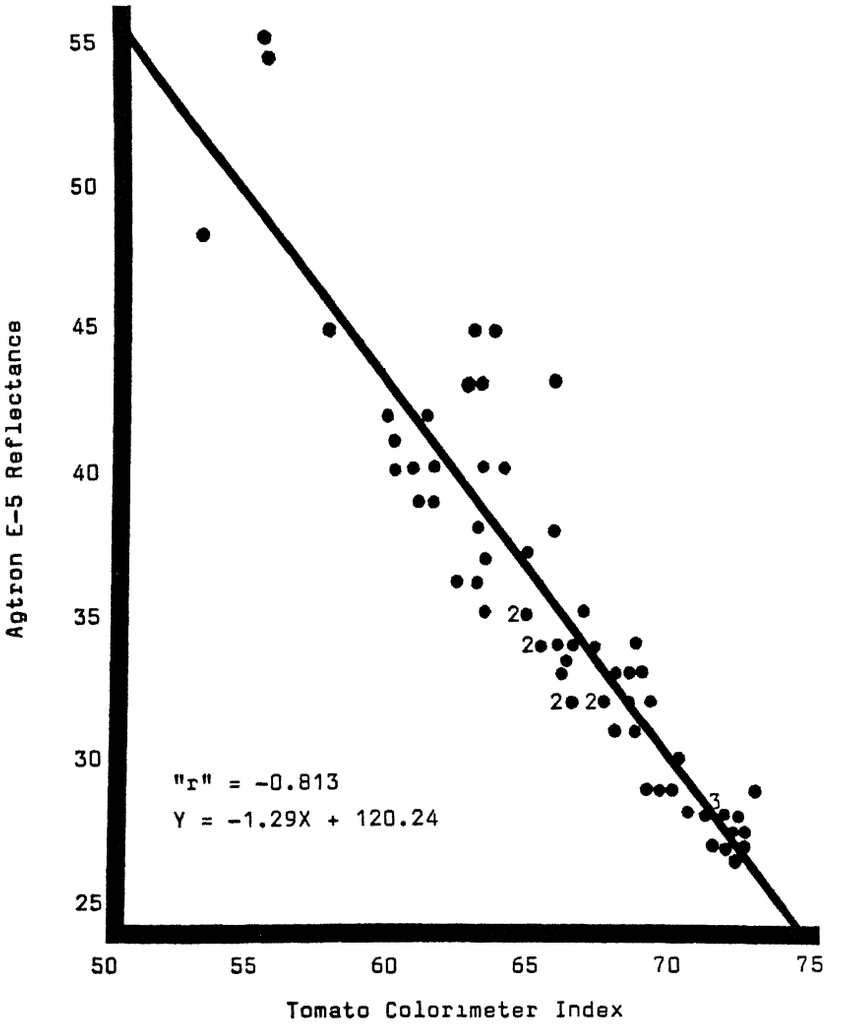

FIG. 3.--Correlation Coefficient and Regression Line Comparing Agtron E-5 and Hunter D-6 Tomato Colorimeter for Tomato Juice Color.

FLAVOR EVALUATION OF TOMATO JUICE FORTIFIED WITH SUGAR AND CITRIC ACID

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Tomato juice per capita consumption has been steadily declining from a high in 1963 of 5.4 lb. to 3.8 lb. in 1973. During this same period, canned whole tomato per capita consumption has risen from 4.6 lb. in 1963 to 5.0 lb. in 1973. One possible explanation is the lack of standardized quality in tomato juice contrasted with the standardized quality of canned tomatoes and other tomato products.

The objective of this research was to establish acceptability limits for percent soluble solids, percent total acidity, and pH to improve tomato juice flavor.

Materials and Methods

Three lots of tomato juice, Fireball cultivar, New Yorker cultivar, and a mixture of Ohio cultivars, were processed at The Ohio State University Food Processing Pilot Plant. Known amounts of salt, ascorbic acid, citric acid, and sucrose were added to each lot of tomato juice. After processing, the cans were stored for approximately 2 months prior to taste panel and quality evaluation.

The samples were evaluated by 20 graduate and upperclass students in a triangular-scoring panel. Each sample used in the taste panel was analyzed for pH, percent total acidity (calculated as citric acid), and percent soluble solids. Soluble solids/total acidity ratios were than calculated.

Taste panelists were eliminated if at the 5% level of significance they could not distinguish between tomato juice samples in the triangle taste panel evaluation. The taste panels were then analyzed for significance as to the ability to distinguish between the samples.

For taste panels when the judges could discriminate between the samples, the two-way analysis of variance was determined for the flavor preference scores and the F-statistic was evaluated for significance.

Results

The data in Table 1 indicate those taste panels in which the judges could not distinguish the odd sample at the 5% level of significance. As can be seen from the data, the greatest difference in pH which panelists could not detect was 0.16 pH units. The greatest difference in the percent total acidity (calculated as citric) was 0.12% and the greatest difference in the percent soluble solids content was 0.1%. The greatest difference in the soluble solids/total acidity ratio which panelists could not detect was 3.0.

The data in Table 2 illustrate the triangle taste panels where the judges could detect the odd sample at the 5% level of significance. The analysis of variance was determined for the preference scores. For any two samples when the scores were not statistically different, it can be stated that there was no difference in preference among the judges of the samples. Thus, from examination of the data it can be noted that those samples with a soluble solids/total acidity ratio difference of greater

than 3.2 had statistically different preferences. Those samples with a difference in soluble solids/total acidity ratios less than 3.2 were preferred the same. Thus, with soluble solids/total acidity ratio differences less than 3.0, taste panelists either could not detect a difference in flavor or they had no difference in preference among the samples.

Tomato juice samples receiving the highest preference scores had pH values between 4.20 and 4.30; percent total acidity values between 0.40 and 0.58; percent soluble solids values between 6.0 and 8.0; and soluble solids/total acidity ratios between 12 and 15. Tomato juice samples with a soluble solids/total acidity ratio less than 10 or greater than 18 are unacceptable for flavor. Tomato juice samples with a percent total acidity content greater than 0.60% should have additional sucrose added to be rated acceptable. Tomato juice samples with a percent total acidity content less than 0.40 were rated unacceptable for flavor.

TABLE 1.--Triangle Taste Panel Evaluation, Judges Not Able to Distinguish Odd Sample at 5% Level of Significance.

Panel No.	Sample*	pH	Percent Total Acidity (T.A.)	Percent Soluble Solids (S.S.)	S.S./T.A. Ratio
1	3a	4.20	0.47	6.8	14.5
	5a	4.08	0.59	6.8	11.5
	difference	0.13	0.12	0	3.0
2	7b	4.38	0.48	6.0	12.5
	8b	4.22	0.57	6.1	10.7
	difference	0.16	0.09	0.1	1.8
3	10b	4.39	0.48	7.3	15.2
	12b	4.28	0.54	7.3	13.5
	difference	0.11	0.06	0	1.7
4	9b	4.21	0.51	6.8	13.3
	11b	4.20	0.54	6.8	12.6
	difference	0.01	0.03	0	0.7

*Sample codes are as follows: a -- mixture of Ohio cultivars; b -- New Yorker cultivar.

TABLE 2.--Triangle Taste Panel Evaluation, Judges Able to Distinguish Odd Sample.

Panel	Sample	pH	Percent Total Acidity (T.A.)	Percent Soluble Solids (S.S.)	S.S./T.A. Ratio	Average Flavor Score
1***	10c	4.20	0.26	6.2	23.8	4.5
	8c	4.03	0.50	5.4	10.8	6.5
	difference	0.17	0.24	0.8	13.0	2.0*
2***	7c	4.35	0.47	6.5	13.8	7.8
	9c	4.29	0.26	5.4	20.8	3.9
	difference	0.06	0.21	1.1	7.0	3.9**
3**	10b	4.42	0.47	7.8	16.6	6.9
	8b	4.28	0.58	6.6	11.4	4.6
	difference	0.14	0.11	1.2	5.2	2.3**
4***	2c	4.12	0.47	5.6	11.9	6.2
	1c	4.30	0.39	5.9	15.1	6.0
	difference	0.18	0.08	0.3	3.2	0.2 ns
5***	12b	4.28	0.54	7.2	13.3	7.6
	8b	4.18	0.56	6.2	11.1	6.3
	difference	0.10	0.02	1.0	3.3	1.3**
6***	6a	4.08	0.61	8.0	13.1	6.4
	4a	4.22	0.47	7.2	15.3	5.7
	difference	0.14	0.14	0.8	2.2	0.7 ns
7***	11b	4.20	0.60	6.8	11.3	6.3
	7b	4.38	0.47	6.0	12.8	6.6
	difference	0.18	0.13	0.8	1.5	0.3 ns
8*	1b	4.48	0.47	6.4	13.6	7.4
	2b	4.30	0.53	6.4	12.1	6.5
	difference	0.18	0.06	0	1.5	0.9 ns
9***	8b	4.21	0.58	6.0	10.3	6.1
	10b	4.20	0.58	6.8	11.7	6.6
	difference	0.01	0	0.8	1.4	0.5 ns
10***	5a	4.10	9.56	6.8	12.1	5.8
	6a	4.01	0.63	8.0	12.7	5.5
	difference	0.09	0.07	1.2	0.6	0.3 ns

*Significant at the 5% level; **significant at the 1% level; ***significant at the 0.1% level; ns = not significant at the 5% level.

Sample Codes: a - mixture of Ohio cultivars; b -- New Yorker cultivar; c -- Fireball cultivar.

EFFECTS OF CITRIC ACID AND SUGAR RATIOS ON THERMAL RESISTANCE OF BACILLUS COAGULANS VAR. THERMOACIDURANS IN TOMATO JUICE

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The *Bacillus coagulans* var. *thermoacidurans*, a falcultative anaerobe causing flat-sour spoilage in tomato juice, continues to be a problem.

With improved quality as a goal, consideration is being given to permit the addition of citric acid and sugar to tomato juice for better control of flavor. Control of spoilage by adjustment of pH in tomato juice has been acknowledged and investigated by several investigators (1), (2), and (3). The use of citric acid to adjust pH to 4.0 or 4.2, depending on spore load, to control growth of *B. coagulans* has been well documented by the above researchers.

In this study, both citric acid and sugar were evaluated to determine the effects of sugar-acid ratio on *B. coagulans*.

Equipment and Procedure

The culture used was strain number 7050 of *B. coagulans* ATCC. Recovery medium used was a modified *thermoacidurans* agar developed by Stern, Hegarty, and Williams (4). A commercial juice was used and divided into four portions. One portion was analyzed for pH, titratable acidity, and soluble solids. The other three portions were adjusted with citric acid to increasing 0.5% increments of titratable acidity. All four portions were then adjusted using sucrose to increasing 0.5% increments of soluble solids.

Spores were prepared and inoculated into Thermal Death Time tubes with tomato juice to give an approximate inoculum of 100,000 spores per ml. of tomato juice. T.D.T. tubes were placed in a wire mesh basket, immersed in oil for an appropriate time, and then removed and immediately cooled down and agitated. The tubes were then aseptically broken and contents were diluted and plated.

Results

Sugar had an insignificant effect on heat resistance but the addition of citric acid could be significant. A 0.2% addition had the effect of lowering the pH significantly which has been previously alluded to as preventing germination of *B. coagulans* spores and also reducing heat resistance by 35%. This reduced heat resistance combined with a pH phenomenon could be used to assure safe processes for even shorter process times.

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PROTEIN BODIES OF THE GERMINATING TOMATO SEED COTYLEDON

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Introduction

In recent years interest has developed in the area of food processing waste utilization. The tomato processing industry alone generates more than 3 million tons of waste annually. On the basis of weight, approximately 51% of the waste consists of seeds. The seeds contain about 29% protein and are high in amounts of the amino acids lysine and threonine.

Since the protein in tomato seeds is of interest to food technologists, this project was initiated in an attempt to photograph the membrane-bound protein bodies occurring in the seeds and to observe the changes taking place in these protein bodies throughout the course of germination.

The preparation of seeds for study under the electron microscope has proven to be difficult. Mollenhauer and Totten[1] stated that inadequate methods and chemicals for the preservation of seeds for electron microscopy have hindered studies in this area. They reported that fixative and plastic penetration is inhibited by the density of cell walls and secreted slimes, as well as by the dehydrated state of the seed tissues.

Methods and Materials

Tomato seeds (Campbell 28, Lot 412-006, Petoseed, 1972) were germinated for various times on moist filter paper pads in plastic petri dishes at room temperature. After the appropriate germination time, the seeds were dissected and small pieces of cotyledon were excised from several seeds. The cotyledon pieces were then immediately placed in the appropriate fixatives.

Three different methods of fixation were used and compared. In the first method, tissues were fixed for 3 hours (room temperature) in 6% glutaraldehyde which had been prepared in 2% phosphate buffer (pH 7.1). Following fixation, the tissues were washed for 8 hours with several changes of phosphate buffer. The tissues were then post-fixed in 2% phosphate buffered OsO_4 for 2 hours at room temperature. Following the post-fixation period, the samples were rinsed in several changes of phosphate buffer and were then dehydrated for 10 minutes each in 25, 50, 75, and 95% ethanol and in three 10-minute changes of 100% ethanol.

In the second method, the seed tissues were fixed in 2% unbuffered $KMnO_4$ for 2 hours at refrigerator temperature. Washing and dehydration were conducted as described above.

The third method involved fixing tissues in a 3% glutaraldehyde, 1.5% paraformaldehyde, 1.5% acrolein on a drop of lead citrate for 2 minutes, rinsing in distilled

[1] Mollenhauer, H. H. and C. Totten. 1971. Studies on seeds and fixation of seeds. J. Cell Biol., 48:387-394.

water, and allowing to air dry. All grids were viewed with a Zeis EM-9A electron microscope.

Results and Discussion

Three separate methods of processing tomato seed cotyledons at various stages of germination were examined in this study. The first method involved fixation in 6% glutaraldehyde for 3 hours at room temperature followed by 2% OsO_4 for 2 more hours at room temperature. No electron micrographs were obtained from this method. The tissues were not evenly fixed and infiltration was poor.

The second method gave better results. In this method, the seed tissue was fixed in 2% unbuffered $KMnO_4$ for 2 hours at 4° C. Examples of the $KMnO_4$ fixation are seen in Figs. 1-4. With $KMnO_4$ there is a deposition of electron-opaque manganese dioxide at the sites of membranes, thereby fixing membranes. Contrast was poor on these plates, even after post-staining with uranyl acetate and lead citrate. Fixation and infiltration were even throughout the tissue and sectioning was possible on the 1 through 4-day germination samples. The 6 through 8-day samples were not infiltrated well and sectioning was not possible.

Method three involved a fixative mixture of glutaraldehyde to maintain cellular form, acrolein for deep penetration, and paraformaldehyde for the preservation of protein bodies. This was followed by subjecting the tissues to either OsO_4 or $KMnO_4$. An example of this technique can be seen in Fig. 5. It shows that there was preservation of subcellular components. Mitochondria, endoplasmic reticulum, and chloroplasts can be seen. The tomato seeds germinated for 5 days were not fixed as well as the 12-hour sample and sectioning of this older germinating tissue was difficult.

The quality of the electron micrographs was not as good as those obtained from the younger germinating samples of method two or three. Longer fixation times and also a longer infiltration schedule might remedy this problem.

It is evident from these results that one method of fixation alone is inadequate for preparing tomato seed germination series for electron microscopy. Throughout the course of germination, the seeds become hydrated and complex biochemical reactions and tissue changes take place. These tissue and biochemical changes can affect the penetration of fixatives and embedding materials. Although method two was acceptable for the 1 through 3-day germination series, it was not adequate for the older germinating cotyledon tissue. Method three worked well for the younger germinating seeds but was less acceptable for the 5 through 7-day tissue.

In summary, method two or three would be the methods of choice for the younger germinating tissues, while a modification of method three would be chosen for the 5 through 7-day samples. The choice of methods would depend on the type of seed and the particular seed tissue being studied.

It was of major interest in this study to observe cytological changes in sections of tomato seed cotyledons on germination. The sequence of changes in the protein bodies are shown in Figs. 1, 3, and 4. A cotyledonary cell 12 hours after the start of germination typically looks like the cells seen in Fig. 1. The protein bodies, which stained evenly with $KMnO_4$ or OsO_4, are enclosed by a membrane. Surrounding the protein bodies are numerous sac-like or spherical particles. These are somewhat smaller than the protein bodies and are the locations of lipid and enzyme deposits. These particles are designated as spherosomes and they can be seen to

be membrane bound (Fig. 2). It is of interest to note the mitochondria, endoplasmic reticulum, and young chloroplasts in Fig. 5.

At 3 days after the start of germination, the protein bodies appear to swell or enlarge and cavities around the outer edges of the protein bodies are obvious. A loose sponge-like structure of the protein mass also begins to appear. Figs. 1, 3, and 4 demonstrate the breakdown of protein within the protein bodies. Eventually, the membrane-bound protein bodies coalesce and disappear.

Conclusions

Tomato seeds have been shown to contain tissues and cells which have accumulated and stored quantities of protein in membrane-bound bodies. During the course of germination, these proteins are metabolized and the changes in and the final disappearance of the protein bodies can be seen via electron microscopy.

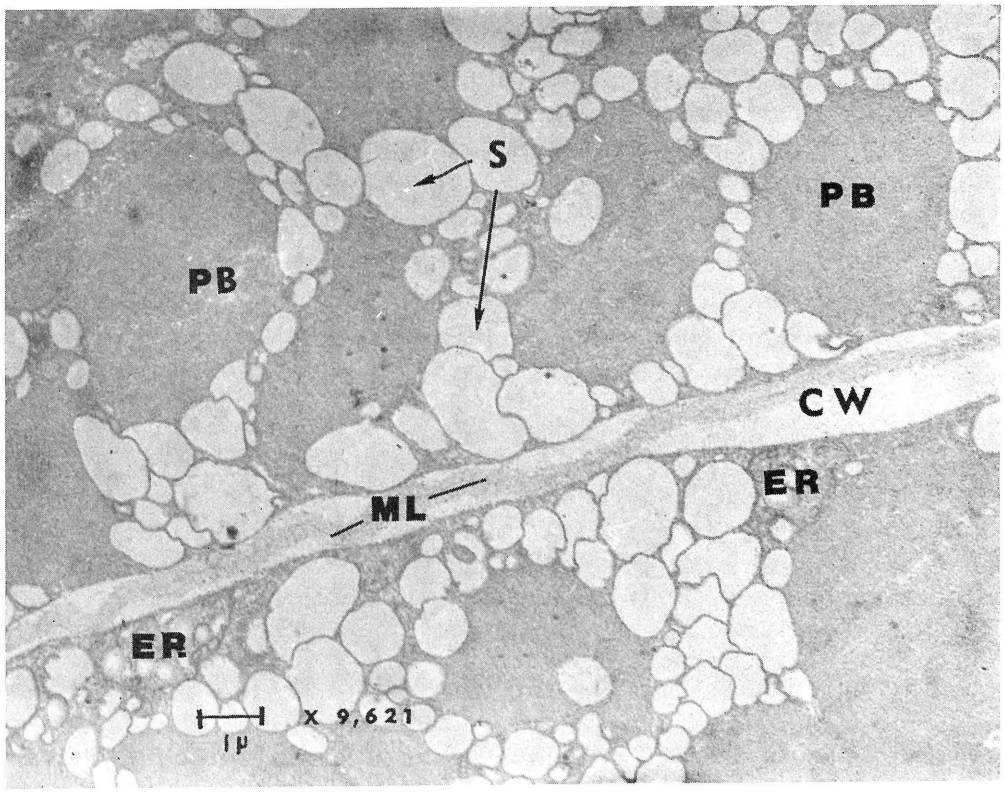

FIG. 1.--Tomato seed germinated for 12 hours. The cotyledon was prefixed with 6% glutaraldehyde and post-fixed in 2% $KMnO_4$. Magnification = 9,621 x; PB = protein body; S = spherosome; CW = cell wall; ML = middle lamella; ER = endoplasmic reticulum.

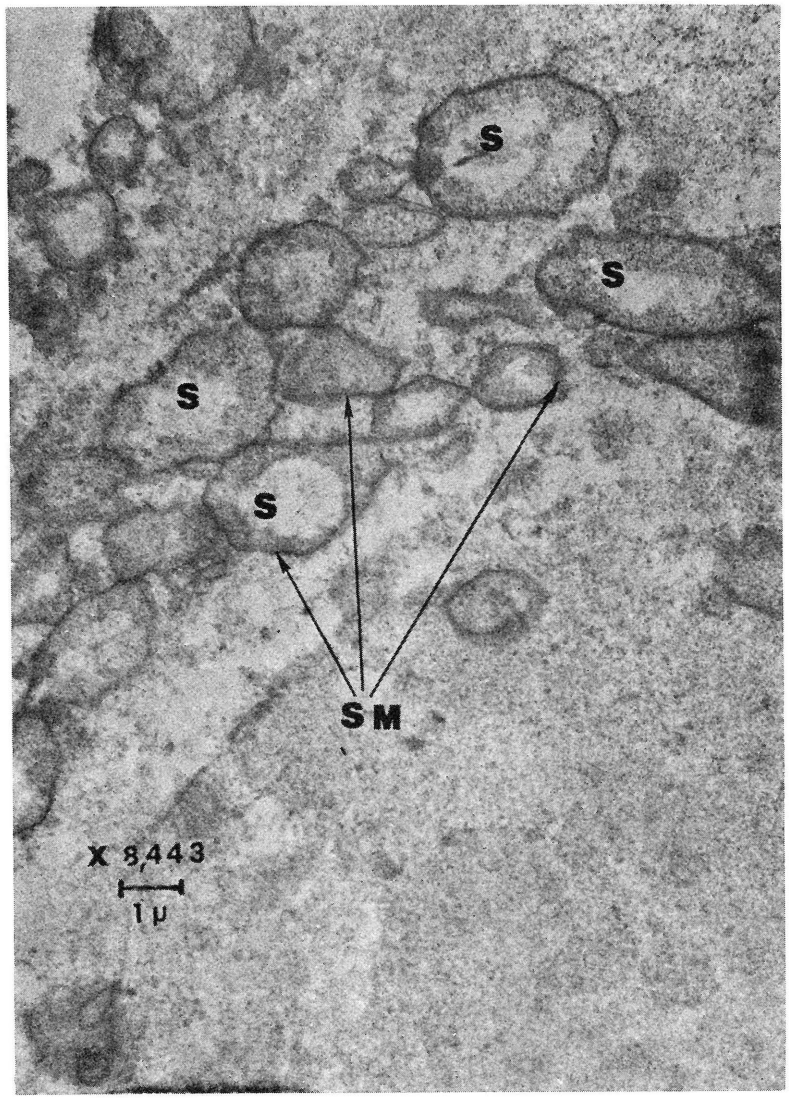

FIG. 2.--Tomato seed germinated for 24 hours. The cotyledon was prefixed with 6% glutaraldehyde and post-fixed in 2% $KMnO_4$. Magnification = 8,443 x; S = spherosome; SM = membrane around spherosome.

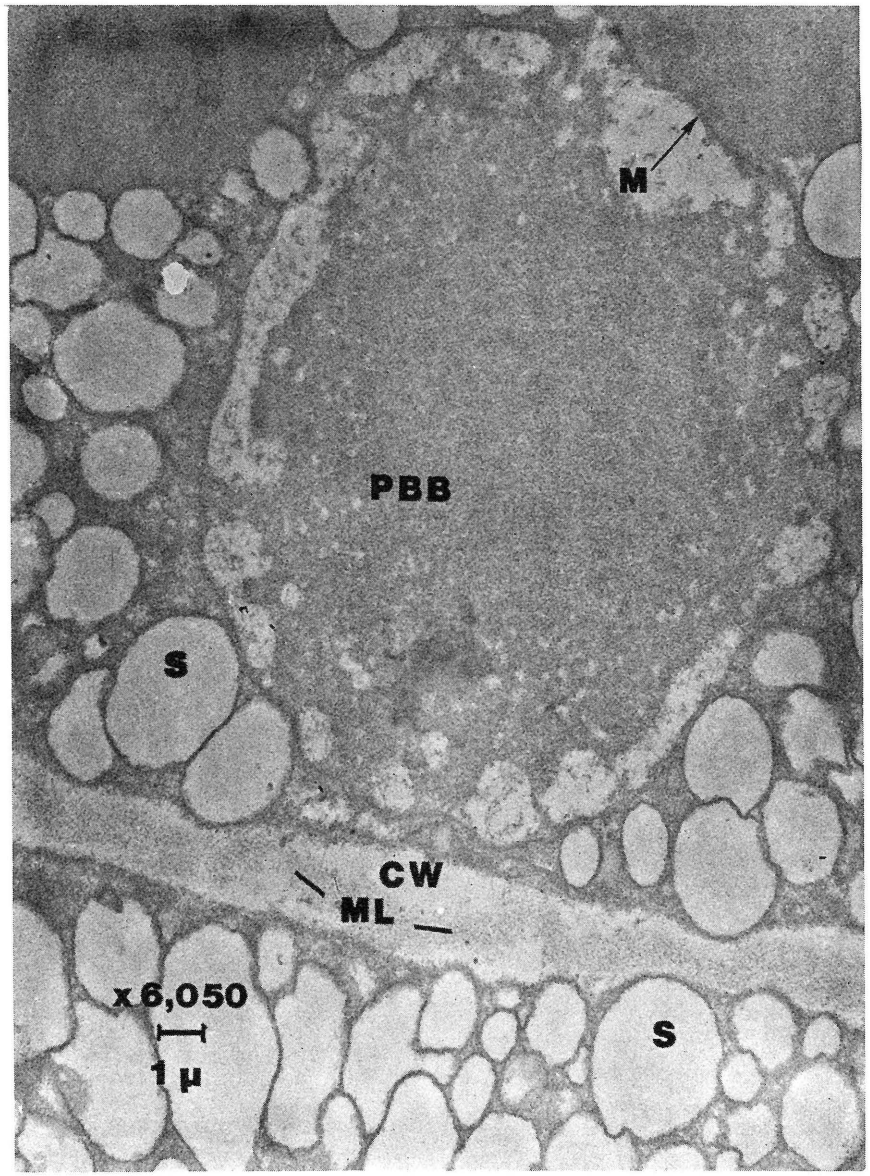

FIG. 3.--Tomato seed germinated for 3 days. The cotyledon was prefixed with 6% glutaraldehyde and post-fixed in 2% $KMnO_4$. Magnification = 6,050 x; PBB = protein body breakdown; M = protein body membrane; S = spherosome; CW = cell wall; ML = middle lamella.

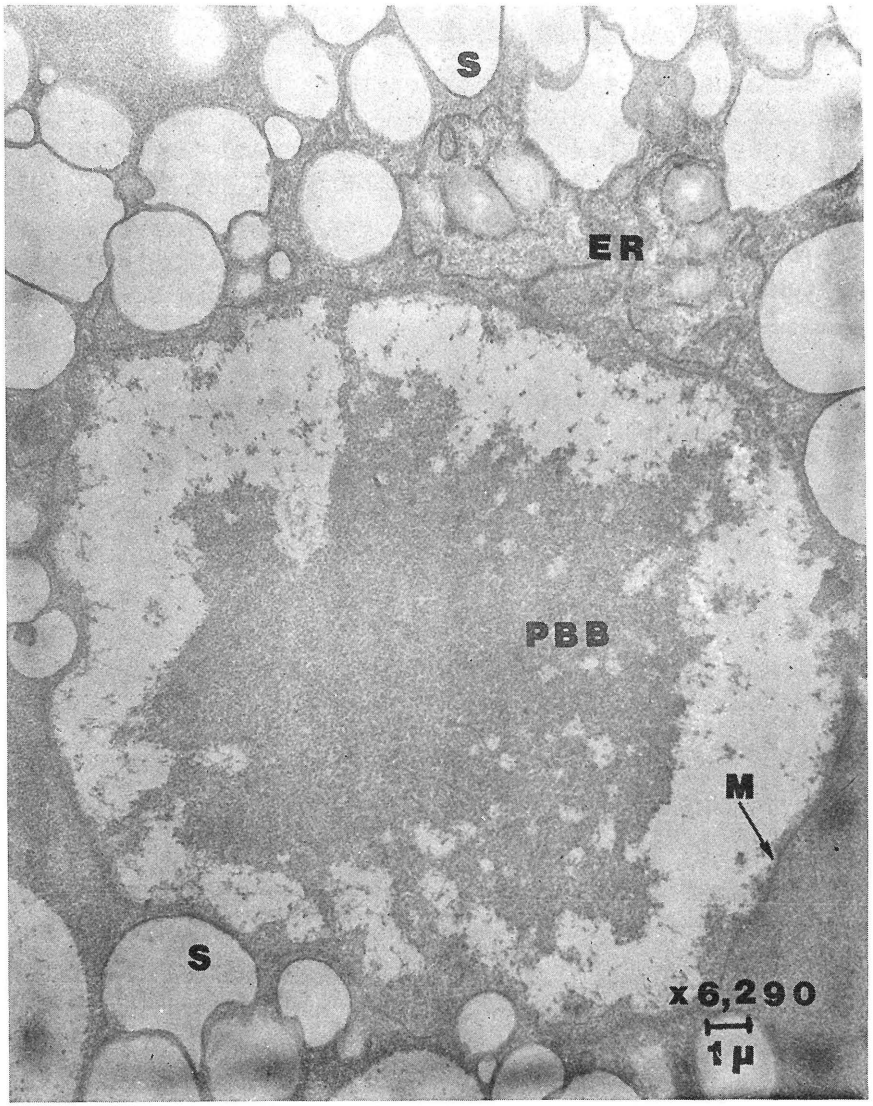

FIG. 4.--Tomato seed germinated for 4 days. The cotyledon was prefixed with 6% glutaraldehyde and post-fixed in 2% $KMnO_4$. Magnification = 6,290 x; S = spherosome; ER = endoplasmic reticulum; PBB = protein body breakdown; M = protein body membrane.

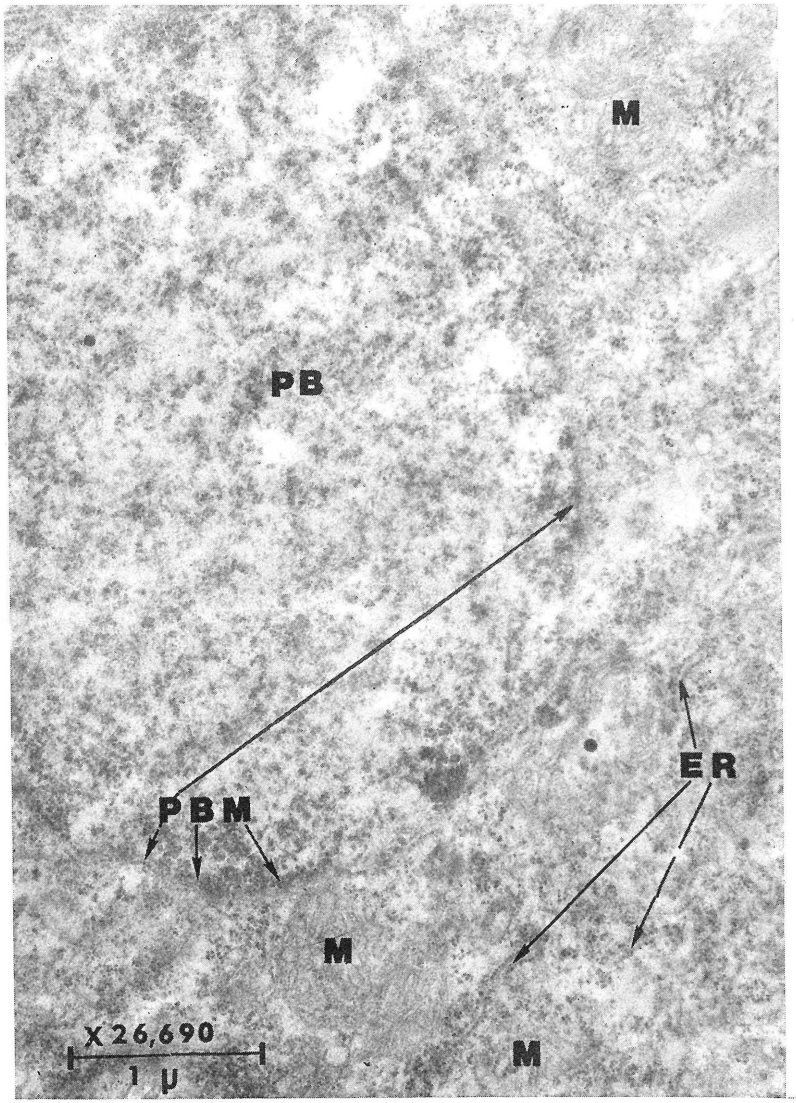

FIG. 5.--Tomato seed germinated for 12 hours. The cotyledon was prefixed with 3% glutaraldehyde, 1.5% paraformaldehyde, and 1.5% acrolein. It was then post-fixed with 1.5% OsO_4 buffered in phosphate buffer. Magnification = 26,690 x; PB = protein body; M = mitochondria; ER = endoplasmic reticulum; PBM = protein body membrane.

STUDIES CONCERNING THE PROTEIN OF TOMATO SEEDS RECOVERED FROM TOMATO CANNERY WASTE

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Introduction

Recent USDA statistics indicate that the annual commercial crop of tomatoes for processing in the United States is approximately 7 million tons, almost 3 million tons of which become processing waste. Projected estimates suggest that the quantity of tomato cannery waste will soon double. Tomato waste is a major disposal problem for Ohio tomato product processing plants. Discussion in the Department of Horticulture at The Ohio State University and with representatives of the tomato product processing industry suggested the importance of the recovery and utilization of tomato seeds, a major component (51%) of this cannery waste.

Hollingsworth and Greaves (2) stated that the most common nutritional deficiency diseases in the world today are the protein-calorie deficiency diseases and that new or unconventional sources of protein need to be investigated. The major objective of this study was to obtain data on the quantity and quality of tomato seed protein and to provide a basis for the utilization of seeds from tomato cannery waste as a source of food or feed grade protein. Specific objectives included separation of the seeds from tomato cannery waste, determination of the amount of protein present in tomato seeds, determination of the solubility and extractability of the protein in tomato seeds, and determination of the amino acid composition of tomato seed protein.

Methods and Materials

Whole tomato waste was obtained from the Minster Canning Company, Minster, Ohio, in the fall of 1973. The seeds were separated from the whole waste by flotation and allowed to dry for 48 hours in a forced air oven at 28° C.

Seeds for protein extraction studies were of mixed greenhouse and field cultivars Specific greenhouse cultivars 909-13, Mo-533, and M-R 13 were used in an experiment to determine the amount of protein in different tomato seed cultivars. The seeds were then either stored at room temperature until further use or were ground in a Wiley mill fitted with a No. 40 mesh screen. When whole seed meal was to be used, it was freshly ground for each experiment. For most experiments, however, the ground seed meal was defatted with a 2:1 (v/v) ratio of chloroform and methanol. Twenty grams of seed meal were mixed with 200 ml. of the chloroform-methanol mixture and blended for 3 minutes in a Waring Blendor. The slurry was then filtered through a Buchner funnel fitted with No. 1 Whatman filter paper. The seed meal was dried and the solvent allowed to evaporate in a forced air oven for 48 hours at 28° C.

To determine the weight of seeds contained in whole waste, similar portions of whole waste were forced air dried at 28° C. for 48 hours and then weighed. The waste was then subjected to flotation and the seeds separated from the skins, cores, and peels. The two fractions were again dried, weighed, and the percent weight of seeds contained in whole tomato cannery waste calculated.

Protein was extracted from defatted tomato seed meal by mixing a 1:10 (w/v) ratio of seed meal with either distilled water, 0.1 M NaCl, 0.5 M NaCl and 0.25 M ascorbic acid, or 0.5 M sucrose. The slurry was slowly stirred on a magnetic stirrer for 30 minutes at room temperature. All extracts were then analyzed for protein.

The extractability of tomato seed protein as a function of pH was obtained by stirring defatted seed meal in distilled water (a meal-water ratio of 1:10, w/v) at room temperature for 30 minutes. Next, 1 N HCl or NaOH was added to vary pH. The extracts were centrifuged for 10 minutes at 12,000 g's and were then analyzed for protein. The effect on solubility as a function of ionic strength was determined by stirring defatted seed meal (meal water ratio of 1:10, w/v) in NaCl solutions of varying ionic strength, centrifuging, and again analyzing the extracts for protein.

The amount of protein present in the liquid samples obtained throughout these studies was determined by the method of Lowry (3) and by the Biuret method (5). In both methods, standard curves were constructed for each experiment. The standard proteins used were bovine serum albumin (fraction V) and zein. Distilled water was used in all control tubes. Absorbance was read at 555 nm in a Gilford Model 2400 Spectrophotometer which had been fitted with a rapid sampling device and a digital print-out. The micro-Kjeldahl method as described by Ma and Zuazaga (4) was used to determine the amount of crude protein in the dry ground seed samples. All protein determinations were carried out in triplicate for each experiment conducted.

The OARDC Department of Agronomy conducted and reported the quantitative amino acid analyses on dry ground tomato seed meal samples. All samples were hydrolyzed in 6 N HCl at 110° C. for 24 hours and 0.4 ml. of the diluted aliquot injected into the instrument. The instrument used was a Beckman model 120-B amino acid analyzer.

Results and Discussion

It was found that the seeds were easily separated from the tomato waste by flotation and that the seeds comprised, on the average, 51% of the waste by weight. Recovery of seeds by a flotation method could be used by processors with little expense and technical ability to reduce the amount of solid waste to be disposed.

The possibility of tomato processors utilizing the seeds as a protein source was also investigated. Whole cannery waste was found to contain approximately 15% protein, while the tomato seed meal from the cannery waste seeds was found to contain about 26% crude protein according to the micro-Kjeldahl method (N x 5.85). Defatted seed meal from the cannery wasted seeds contained about 29% protein. Campbell-28, a field cultivar, was determined to contain 25.6% protein, while the seeds from the greenhouse cultivars contained slightly lower percentages of crude protein. These results are shown in Table 1.

The effects of pH and ionic strength on protein solubility and the extractability of protein from tomato seeds are shown in Tables 2, 3, and 4. Since the majority of proteins in oilseeds are contained in membrane-bound protein bodies, extraction of protein is often difficult and incomplete.

The experiments conducted for this study indicated that at a neutral pH of 7.2, 9.1% (or approximately 1/3 of the total protein available in the tomato seeds) can easily be made soluble. It was also found that a NaCl solution (0.50 ionic strength) was effective in extracting 7.3% crude protein, but these samples required extensive and time-consuming dialysis after extraction in order to remove the NaCl. Subjecting the ground tomato seed to heat or to solvents utilizing a combination of pH and ionic strengths could perhaps increase the amounts extracted and the ease of protein

TABLE 1.--Protein Content of Whole Tomato Waste and Few Selected Tomato Seed Cultivars as Determined by the Kjeldahl Method.

Material Tested	Percent Protein Extracted*	Range
Whole Tomato Cannery Waste	15.0	14.8-15.3
Cannery Waste Seeds (mixed field cultivars)	25.8	25.3-26.0
Ohio M-R 13	25.3	24.9-25.5
909-13	20.1	19.9-20.8
Mo-533	22.8	21.5-23.0
Campbell-28	25.6	25.1-25.9
Defatted Seed Meal (seeds from cannery waste)	28.9	28.3-29.5

*The average of 15 samples is reported, three runs of each.

TABLE 2.--Amount of Protein Extracted from Defatted Tomato Seed Meal as Function of pH.

pH	Percent Protein Extracted	Range
1.8	7.7	7.1-7.9
3.2	3.7	3.5-3.9
4.5	3.0	2.7-3.3
5.3	4.0	3.5-4.2
5.8	5.2	5.0-5.8
6.0	6.0	5.9-6.5
6.5	7.7	7.0-8.1
7.2	9.1	8.5-9.6
8.5	9.7	9.0-9.9
11.2	11.0	10.8-11.6

TABLE 3.--Amount of Protein Extracted from Defatted Tomato Seed Meal as Function of Ionic Strength.

Ionic Strength	Percent Protein Extracted*	Range
0.50	7.3	6.8-7.5
0.10	6.6	6.1-6.9
0.05	6.0	5.4-6.6
0.02	5.5	5.0-5.7
0.01	5.2	5.0-5.8
distilled water	5.2	4.9-5.5

*The average of 15 samples is reported, three runs of each.

TABLE 4.--Protein Extractability Studies.

Extraction Method	Percent Protein Extracted*	Range
0.1 M NaCl	5.6	5.0-5.9
0.5 M sucrose	7.0	6.7-7.3
0.5 M NaCl and 0.25 M ascorbic acid	5.7	4.9-5.5
distilled water	5.2	4.7-5.3

*The average of 15 samples is reported, three runs of each.

extraction. Various solvents used in these studies for protein extraction included 0.5 M sucrose, 0.1 M NaCl, distilled water, and a solution of 0.5 M NaCl and 0.25 M ascorbic acid. The 0.5 M sucrose solution was effective in extracting 7.0% crude protein.

Whole defatted ground tomato seed was analyzed for amino acid composition. Seed meals remaining after extraction with various solvents were also analyzed. The results from these experiments are shown in Table 5.

Tomato seed protein, in comparison to soy flour, was about 13% higher in lysine, 42% higher in arginine, and about 49% higher in threonine. Tomato seed protein, however, contained only about one-ninth the amount of cystine and only about one-half the amount of methionine as the soy flour. Similarly, in comparison to corn (opaque-2), the tomato seed protein was high in lysine, threonine, and arginine, but low in methionine, cystine, and leucine. It is interesting to note that tomato seed protein contains about 60% more threonine per 100 grams of protein than egg or milk protein. Lysine amounts in egg, milk, and tomato seed protein are about the same (Table 6). Amounts of sulfur-containing amino acids present in tomato seed protein are low in comparison to egg and milk protein. Tryptophan was not analyzed in these studies.

Proteins deficient or low in amino acids can be corrected in whole or in part by protein supplementation. A protein presenting a poor amino acid balance could be mixed with another protein which contained an amino acid limiting in the first protein. Therefore, each tends to make up for the deficiencies of the other. Bressani *et al.* (1) stated that the cereal grains are mainly deficient in lysine, although other essential amino acids are also limiting. The findings of these experiments point to the possibility of using tomato seed protein as a supplementing protein since the tomato seed appears to contain high amounts of lysine.

It can also be seen from the differences in amino acid composition in Table 5 that the choice of solvent has an effect on the protein extracted. Sample one, which was extracted once with distilled water, was much lower in phenylalanine, tyrosine, and threonine than the original unextracted tomato seed meal, while there was little change in the amount of lysine. Samples two and three, which were extracted with 0.5 M NaCl and 0.5 M NaCl plus 0.25 M ascorbic acid, respectively, were lower in lysine as well as the other amino acids. These differences in amino acid composition indicated that different amounts and kinds of proteins can be extracted by utilizing different solvents.

TABLE 5.--Amino Acid Composition of Various Tomato Seed Meals, Grams of Amino Acid per 100 Grams Protein.

Amino Acid	Sample 1	2	3	4	5	6
Lysine	6.0	3.4	3.4	6.6	5.8	4.8
Histidine	2.9	1.5	1.5	2.9	2.3	3.3
Asparagine	7.6	5.5	5.8	10.3	5.8	8.5
Aspartic Acid	8.0	6.3	4.1	6.7	-	10.8
Threonine	2.5	1.1	1.4	7.8	4.0	4.0
Serine	1.8	1.3	0.9	2.1	-	4.8
Glutamic Acid	7.9	3.3	0.7	11.9	-	17.5
Proline	5.5	5.7	4.3	6.0	-	7.6
Glycine	2.4	0.9	1.2	3.3	-	4.8
Alanine	5.0	3.8	4.8	5.3	-	6.6
Cystine	0.1	0.2	0.2	0.2	0.9	1.7
Valine	4.9	3.5	3.5	4.6	4.2	5.1
Methionine	0.5	0.4	0.2	0.1	2.0	2.1
Isoleucine	4.3	3.1	3.1	4.4	4.7	3.4
Leucine	2.6	2.0	1.7	2.6	6.6	9.1
Tyrosine	0.7	0.7	0.7	3.4	4.1	4.0
Phenylalanine	0.8	0.7	0.7	3.9	5.7	4.5

Sample 1 = Whole defatted ground tomato seed after one extraction with distilled water.
Sample 2 = Whole defatted ground tomato seed after one extraction with 0.5 M NaCl.
Sample 3 = Whole defatted ground tomato seed after one extraction with a 0.5 M NaCl, 0.25 M ascorbic acid medium.
Sample 4 = Whole defatted ground tomato seed.
Sample 5 = Soybean flour.
Sample 6 = High lysine corn (opaque-2).

TABLE 6.--Essential Amino Acids in Tomato Seed Protein (TSP), Egg, and Milk Protein.

	Grams Amino Acid per 100 Grams Protein		
Amino Acid	TSP	Egg	Cow's Milk
Isoleucine	4.4	6.6	6.4
Leucine	2.6	8.8	9.9
Lysine	6.6	6.4	7.8
Phenylalanine	3.9	5.8	4.9
Tyrosine	3.4	4.2	5.1
Cystine	0.2	2.4	0.9
Methionine	0.1	3.1	2.4
Threonine	7.8	5.1	4.6
Tryptophan	-	1.6	1.4
Valine	4.6	7.3	6.9

Summary and Conclusions

Tomato cannery waste was subjected to flotation. On the basis of weight, about 51% of the waste was recovered as tomato seeds. These seeds were analyzed for protein and were found to contain approximately 29% crude protein. Extractability of the protein from the seeds was incomplete but was found to be influenced by pH, ionic strength, and the solvent medium. A pH of 7.2 extracted 9.1% protein while a NaCl solution (0.5 ionic strength) extracted 7.3% protein. A 0.5 M solution of sucrose was effective in extracting about 7% protein. Amino acid analysis conducted on ground tomato seed showed that in comparison to high lysine corn and soy flour, tomato seed protein was high in lysine, threonine, and arginine but low in the sulfur-containing amino acids.

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LIPID COMPOSITION OF CUCUMBER

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Cucumber is one of the major vegetable crops in Ohio. Cucumbers for pickles ranked No. 5 in production and No. 6 in dollar value in Ohio in 1974. Per capita pickle consumption is also increasing. In addition to their economic importance, vegetables including cucumber are essential in human diets and health.

The purpose of this investigation was to analyze total cucumber lipids, lipid classes, and their fatty acid composition in order to provide in-depth information for processors, food technologists, and researchers interested in vegetable lipids.

Fresh cucumber (*Cucumis sativas* L.) (cultivar unknown) was obtained from the J. M. Smucker Co., Medina, Ohio. Lipids were extracted by chloroform-methanol solution (2:1, v/v) and separated into three classes of neutral lipids, glycolipids, and phospholipids by silicic acid and Florisil columns. Each fraction was monitored by thin-layer chromatography. The fatty acid composition was determined qualitatively and quantitatively by gas-lipid chromatography in terms of its methyl ester derivatives.

The average moisture content of fresh cucumber was 95.80%, while average total lipid content was 0.14%. Glycolipids were the highest, 60.0%, which is logical in a photosynthetic green plant; followed by neutral lipids, 29.6%; and phospholipids the least, 10.4%.

The major fatty acids found in cucumber are presented in Table 1. The data show that the predominant fatty acids in total lipids and neutral lipids were palmitic, linoleic, linolenic, and tetracosanoic acids. Glycolipids were mainly lauric, palmitic, stearic, linolenic, and tricosanoic acids, whereas palmitic, stearic, oleic, linolenic, and heneicosanoic acids composed the major fatty acids in phospholipids.

TABLE 1.--Major Fatty Acids in Fresh Cucumber (Percent).

Fatty Acid*	Total Lipids	Neutral Lipids	Glycolipids	Phospholipids
12:0	1.4	1.8	7.8	3.1
13:0	1.1	1.0	-	2.0
14:0	0.6	1.2	3.5	2.3
15:0	0.9	1.2	2.7	2.9
16:0	19.8	11.5	27.9	21.5
18:0	2.9	1.9	5.2	8.6
18:1	1.9	1.2	1.8	5.8
18:2	16.4	3.9	1.6	2.5
18:3	33.0	30.2	17.1	19.7
21:0	2.8	1.7	2.8	4.4
23:0	2.8	-	6.4	-
24:0	5.7	27.6	-	-

*Carbon number : number of double bonds.

FATTY ACIDS IN FRESH AND RECYCLED BRINES

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To better understand changes occurring in cucumbers in recycled brines, a study was undertaken to examine lipids found in these brines. Samples of brines were obtained from the H. W. Madison Co. division of the J. M. Smucker Co., Medina, Ohio. Brines were taken from curing tanks and fresh and recycled 1, 2, and 3 times. Aliquots of the brines were removed and fatty acid composition was determined by gas liquid chromatographic techniques.

Results

The fatty acid composition of fresh and recycled brines is shown in Table 1. The data indicate that the predominant fatty acid in all brines is linolenic. This is followed by caprylic acid and palmitic acid. All three of these acids are highest in the fresh brine. The predominant fatty acids decrease during the first and second recycles but increase in the third recycle. It is also important to note that lauric acid increases directly with the number of times the brine has been recycled. When the shorter chain fatty acids (*i.e.*, those < 12) are considered, the trend was to accumulate these fatty acids slightly as the amount of recycling was increased.

If the saturated vs. unsaturated fatty acid composition of the brines is compared as in Table 2, it is noted that in fresh brine and brine recycled once that the major component is the saturated acids. After two recycles, the major component is the unsaturated fatty acids.

While it is not certain as to the precise role of fatty acids in curing cucumbers, there are at least two ways in which the fatty acids are important. One of these is that certain of the fatty acids are essential to the growth of the microorganisms responsible for pickle fermentation. Being present in recycled brines, particularly at the start of the fermentation, fatty acids could speed up the rate of fermentation and cause a quicker cure. A second role could be as a surface active agent. This could change permeability or diffusion rates in the cucumbers, resulting in a more rapid cure.

The fatty acids are responsible for the characteristic odor associated with recycled brine.

TABLE 1.--Fatty Acid Composition of Fresh and Recycled Brines* (Area Percent).

Fatty Acid†	Fresh	1 Recycle	2 Recycle	3 Recycle
Caprylic (8:0)	20.90	20.12	17.37	18.26
Capric (10:0)	5.17	5.22	6.68	4.93
Lauric (12:0)	1.91	2.21	2.67	3.10
Dodecenoic (12:1)	1.15	1.74	6.01	4.93
Tridecanoic (13:0)	2.49	2.37	-	-
Tridecenoic (13:1)	2.87	3.32	3.87	3.47
Myristic (14:0)	1.72	2.21	2.67	2.55
Myristoleic (14:1)	1.53	1.74	2.94	2.00
Pentadecanoic (15:0)	2.30	2.21	2.67	2.73
Pentadecenoic (15:1)	-	-	-	-
Palmitic (16:0)	11.69	9.19	6.68	9.31
Palmitoleic (16:1)	2.87	3.01	3.34	2.92
Heptadecanoic (17.0)	-	1.10	-	1.46
Heptadecenoic (17:1)	1.43	1.74	2.00	1.82
Stearic (18:0)	2.68	3.48	2.94	4.01
Oleic (18:1)	6.90	4.59	5.21	5.66
Linoleic (18:2)	2.87	3.64	2.67	3.10
Arachidic (20:0)	2.10	2.21	2.54	1.64
Linolenic (18:3)	27.61	27.41	25.26	26.02
?	1.34	1.58	2.80	1.64
Behenic (20:0)	0.38	0.79	1.60	0.36

*GLC determination.

†Carbon number : number of double bonds.

TABLE 2.--Percent Saturated and Unsaturated Fatty Acids Found in Fresh and Recycled Brines.

	Fresh	1 Recycle	2 Recycle	3 Recycle
Saturated Fatty Acids(%)	51.34	51.11	45.82	48.35
Unsaturated Fatty Acids(%)	47.23	47.19	51.30	49.92

REPEATED RECYCLING OF SPENT PICKLE BRINE AFFECTS PICKLE QUALITY

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Introduction

Pollution abatement from food processing plants has continued to attract significant attention. The non-biodegradeability of sodium chloride adds to the pollution problem for processors of many fermented vegetables since salt is necessary to induce the proper fermentation. Henne and Geisman (1973) suggested sodium hydroxide as the best alkaline material for adjusting the pH of spent brines. The system was simple and consisted of the following five steps:

1. Adjust spent brine pH to 11.0
2. Allow 48 hours settling period
3. Decant clear brine layer
4. Adjust pH to 7.0 with hydrochloric acid
5. Incinerate sludge to recover salt and eliminate disposal problem

While the above system was rather inexpensive, other ways to reduce operating costs were investigated. With this in mind, vinegar was substituted for hydrochloric acid since many pickle packers also manufacture their own vinegar. Therefore, the main objectives of this study were: 1) to determine whether vinegar could be used to adjust pH without harmful effects, and 2) to determine the number of times brine could be recycled.

Materials and Methods

The H. W. Madison Co. division of the J. M. Smucker Co. supplied raw materials, tanks, and chemicals. The study was conducted at their plant in Medina, Ohio.

Raw cucumbers were obtained from nearby growers and size graded. Only large size cucumbers (3B) were used for this investigation. Large size cucumbers tend to become hollow during curing. Hollow pickles ("bloaters") represent serious economic losses to pickle packers. The amount of bloaters would give a concrete evaluation of the effect of vinegar on quality, as well as serve as an index indicating when the brine had been recycled too many times.

Spent brine was reconditioned using a sodium hydroxide solution as described. After decanting, the brine was adjusted to neutral with 110 grain vinegar. Spent brines which had been recycled in prior years were treated so that one, two, and three recycles were made. In addition, a tank was put down using fresh salt to serve as a control.

Records were kept on salt content, acidity, and pH of curing brines. These data were used to determine whether the lots cured properly.

After curing for approximately 9 months, the tanks were opened and a 1-bushel sample of each lot was removed for examination. This sample was gathered from as near the center of the tank as possible. Each pickle was sliced longitudinally by hand and evaluated for amount of cure and bloater formation. Records were kept as to type of bloater, *i.e.*, honeycomb, lens, and balloon, and the severity of each

type noted as slight, moderate, or advanced. Twenty-five pickles were examined with a U.S.D.A. pressure tester prior to slicing. Data were recorded and the average pressure was calculated for each lot.

The remainder of the pickles of each tank were sorted through the factory line into usable and unusable based on severity of bloaters obvious from external inspection. Records were kept to determine the degree of reliability of the 1-bushel sample.

Results and Discussion

Changes in acidity and salt content indicated that normal curing occurred in the tanks containing recycled salt brines. It is also important to note that curing took place somewhat more rapidly in recycled brine than in new brine. The number of cycles seemed to influence the rate of cure since the more times the brine was recycled, the faster the cure. The kinetics of curing have not been thoroughly investigated. Based on these results, in-depth studies of this aspect will be undertaken.

When the data for proportions of usable and unusable fruit in the sample and the total tank were compared, it was found that the 1-bushel sample always contained more unusable pickles than the remainder of the tank. However, this difference never exceeded 2 percent. A possible explanation is that in visual and tactile external examinations, some severely bloated pickles could be overlooked. In addition, the close agreement would indicate that the sample taken for intensive evaluation was of adequate size to represent the vat.

The data for the pressure tests are presented in Table 1. These data indicate that pickles cured in recycled brine were firmer than those cured in fresh salt. One possible explanation could be that buffering changed the diffusion rate and speeded up curing.

The distribution of the various types of bloaters is given in Table 2. From these data, it can be seen that as the number of times of recycle is increased, the percentage of good pickles (those without bloaters) increased. The amount of balloon bloaters decreased in proportion to the increase in good pickles. Not only did the type of bloater change with the amount of recycling, but the severity of bloater also changed as illustrated in Table 3.

The data in Table 3 indicate that, in general, the severity of all types of bloaters decreased as the number of recycles increased. It is speculated that buffering capacity of the brines is increased by repeated recycles, speeding up diffusion of the salt into the cucumber. This would drastically reduce the rate of cucumber respiration which would reduce the amount of carbon dioxide released. This aspect will be studied in depth to ascertain the reason for reduction in severity and type of bloaters.

Conclusions

Recycling salt brine for curing cucumbers saves the processor money in salt costs, sewer charges, and surcharges on disposal. In addition, recycling reduces both severity and type of bloaters.

TABLE 1.--U.S.D.A. Pressure Tests for Cucumbers Cured in Fresh and Recycled Brine.

Treatment	Av. Pressure lb./in.^{2}
Fresh Salt	16.4
Recycle 1	18.6
Recycle 2	20.1
Recycle 3	18.4

TABLE 2.--Percentage of Various Types of Bloaters Found in Fresh and Recycled Brine.

Treatment	Good (%)	Lens (%)	Honeycomb (%)	Balloon (%)
Fresh Salt	6.7	16.0	38.2	39.7
Recycle 1	30.0	11.7	26.7	31.7
Recycle 2	38.8	15.7	36.4	9.1
Recycle 3	55.3	7.3	28.4	8.9

TABLE 3.--Degree of Severity of Each Bloater Type by Treatment.

	Lens			Honeycomb			Balloon		
Treatment	Slight %	Moderate %	Advanced %	Slight %	Moderate %	Advanced %	Slight %	Moderate %	Advanced %
Fresh Salt	66.7	28.6	4.8	38.0	50.0	12.0	32.7	50.0	15.3
Recycle 1	21.4	64.3	14.3	43.8	31.2	25.0	10.5	36.8	52.6
Recycle 2	68.4	31.6	0.0	65.9	29.5	4.5	27.3	63.6	9.1
Recycle 3	100.0	0.0	0.0	91.4	5.7	2.9	63.6	36.4	0.0

EVALUATION OF SNAP BEAN CULTIVARS FOR PROCESSING

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Seven varieties of snap beans were grown on the Horticultural Farm at The Ohio State University. The beans were planted in 200-foot rows, 36 inches apart, with the seed placed 2 to 3 inches apart in the row depending on seed size.

At harvest, the plants were pulled and the pods removed by hand. They were transplanted immediately to the Fruit and Vegetable Processing and Technology Pilot Plant. The beans were mechanically snipped, size graded, spray washed, water blanched, and 12 ounces were hand packed into R enamel cans. Two size graders were used, 1-3 and 4-5 sieve sizes. The latter were cut into pieces 1 to 1-1/2 inches long and the smaller size grade were packed as whole beans. The beans were blanched by sizes, using the continuous water blancher set at 175° F. for 3 minutes. Both lots were water cooled prior to inspection and filling.

The canned snap beans were covered with boiling distilled water and a 30-grain sodium chloride tablet was added to the can. The cans were exhausted for 4 minutes, steam flow closed (at 15 psi), and processed at 240° F. and 15 psi for 20 minutes. They were water cooled to 100° F.

The frozen snap beans were filled into R enamel cans, steam flow closed, sealed, coded, frozen in a single contact freezer (-40° F.) and stored at 0° F.

Quality was determined as follows:

No. of plants -- The actual plants in 50 feet were pulled and counted for each harvest.

Yield -- The beans were weighed to determine the gross yield in pounds for the number of plants in 50-foot rows and yield was calculated to ounces per plant.

No. of pods per pound -- The number of pods in a 2 lb., field-run sample was counted.

Percent sieve size -- Sieve size was determined by measuring the diameter of the pod perpendicular to the sutures. The sieve sizes of a 2 lb., field-run sample were determined and weighed. The data are shown by count, percentage by count, and percentage by weight for each sieve size.

Pod length -- Pod length was determined by evaluating 20 pods as to average length reported in inches.

Percent by weight seeds -- This was determined on fresh, canned, and frozen product and reported by sieve size. For determining percent by weight seeds, 100 grams of pods for each sieve size were deseeded and the seeds were weighed.

Texture -- Texture was determined on the GOSUT texturometer. Several pods of each sieve size were used to arrive at the average value. Results are reported directly in GOSUT texturometer values.

TABLE 1.--Snap Bean Raw Product Evaluation, 1974.

Cultivar	Harvest No.	No. Growing Days	No Plants/ 100 Ft.	Yield Oz./Plant	Pods No./Lb.	Sieve Size	Count No./Lb.	Count Percent	Percent by Weight	Average Length (In.)	GOSUT Texture	Percent Seeds
Colorna	I	64	199	2.3	103	1	384	5.8	1.5	2.5	0	
						2	203	9.2	4.6	3.0	3	
						3	164	11.1	7.0	3.2	7	
						1-3	250	26.1	13.1	2.9	3.3	2.0
						4	109	25.7	24.2	3.5	13	
						5	81	11.3	20.3	4.2	22	
						6	75	32.0	43.7	3.0	27	
						4-6	88	69.0	88.2	3.6	20.7	6.4
Colorna	II	67	302	3.2	108	1	256	3.6	1.5	2.5	0	
						2	235	10.0	4.7	3.5	3	
						3	152	8.6	6.2	4.5	7	
						1-3	214	22.2	12.4	3.5	3.3	3.0
						4	111	17.1	17.1	4.5	13	
						5	98	18.0	20.3	4.8	20	
						6	84	39.8	52.3	4.2	20	
						4-6	98	74.9	89.7	4.5	17.7	10.5
Earliwax	I	57	308	1.8	122	1	352	4.6	1.5	3.0	2	
						2	256	11.9	7.8	3.0	9	
						3	169	15.2	10.9	4.0	11	
						1-3	259	31.7	20.2	3.3	7	1.3
						4	110	49.1	54.6	4.0	23	
						5	98	10.6	13.2	4.2	21	
						6	96	8.6	10.9	4.5	22	
						4-6	101	68.3	78.7	4.2	22	6.9
Earliwax	II	67	310	2.9	94	1	-	1.0	0.8	2.5	-	
						2	-	2.1	1.5	4.0	-	
						3	139	6.8	4.6	3.2	13	
						1-3	139	9.9	6.9	3.2	13	4.5
						4	96	31.7	31.2	4.2	23	
						5	90	33.3	35.1	4.0	23	
						6	84	24.8	28.1	4.5	27	
						4-6	90	89.8	94.4	4.2	24	29.1
Early Gallatin	I	64	448	2.6	76	1	384	3.9	0.8	2.0	0	
						2	192	3.9	1.5	3.2	4	
						3	152	12.5	9.4	4.0	7	
						1-3	243	16.4	11.7	3.1	3.7	2.4
						4	87	25.0	21.8	4.8	17	
						5	70	14.4	15.6	4.0	21	
						6	56	40.1	54.6	5.0	24	
						4-6	71	79.5	92.0	4.6	20.7	6.5
Early Gallatin	II	67	468	3.9	79	1	-	0	0	-	-	
						2	213	6.3	2.1	3.0	3	
						3	128	5.0	2.9	3.8	10	
						1-3	170	11.3	5.0	3.4	6.5	1.5
						4	122	12.0	7.1	4.0	13	
						5	66	24.6	27.1	4.8	18	
						6	60	50.6	60.7	5.0	22	
						4-6	83	87.2	94.9	4.6	17.7	10.5
GP 467	I	57	300	2.9	88	1	272	9.7	3.1	3.0	3	
						2	141	12.5	7.8	4.0	7	
						3	122	12.0	8.6	4.5	14	
						1-3	198	34.2	19.5	4.0	8	1.0
						4	103	16.5	14.0	4.5	15	
						5	70	20.0	25.0	5.0	22	
						6	60	29.1	42.1	5.0	27	
						4-6	78	65.6	81.1	4.8	21	4.7
GP 467	II	67	274	5.6	53	1	-	1.0	0	2.2	-	
						2	-	1.0	0	3.5	-	
						3	64	1.9	0	4.2	-	
						1-3	64	3.9	0	3.3	-	1.5
						4	73	7.6	5.5	5.0	15	
						5	51	7.6	7.8	5.0	22	
						6	49	80.9	87.5	5.5	28	
						4-6	58	96.1	100.0	5.2	22	15.5
GP 68-115	I	67	218	4.3	82	1	384	7.4	1.5	2.0	1	
						2	213	12.2	4.6	3.5	8	
						3	141	13.4	7.8	4.0	10	
						1-3	246	33.0	12.4	3.2	6.3	1.5
						4	100	17.1	14.0	4.5	14	
						5	64	14.1	18.0	4.5	19	
						6	54	35.5	53.9	5.5	26	
						4-6	73	66.7	85.9	4.8	19.7	5.3

Percent fiber -- Percent fiber was determined by the official FDA method on the canned snap beans.

Grade -- The grade of the canned and frozen products was determined in accordance with the U. S. Standards for Grades of Canned and Frozen Snap Beans for their respective attributes of quality. The actual score points assigned each of the attributes of quality are recorded by sieve size for each of the cultivars.

Discussion

GP 68-115 had the highest yield of all snap bean cultivars, with 4.3 ounces per plant. GP 467 also had a high yield of 3.8 ounces per plant as an average for two harvests. Earliwax was the lowest yielding cultivar, with an average of 2.4 ounces per plant for the two harvests.

All cultivars had greater than 80% by weight in the 4-6 sieve size for both harvests. Wondergreen was the most mature cultivar, with an average of 93.4% by weight in the 4-6 sieve sizes for both harvests.

The second harvest of Colorna, Earliwax, Early Gallatin, and GP 467 all had high percent fiber values and thus none of the samples received an A grade for quality. Wondergreen had low percent fiber values for all samples and thus received an A grade for all samples.

Colorna and Early Gallatin had all samples in the Grade A category for frozen product quality. Slimgreen had one sample in the Grade C category due to poor color.

TABLE 1 (continued).--Snap Bean Raw Product Evaluation, 1974.

Cultivar	Harvest No.	No. Growing Days	No. Plants/ 100 Ft.	Yield Oz./Plant	Pods No./Lb.	Sieve Size	Count No./Lb.	Count Percent	Percent by Weight	Average Length (In.)	GOSUT Texture	Percent Seeds
Slimgreen	I	64	312	3.8	94	1	288	4.8	1.5	3.0	0	
						2	185	13.9	6.9	3.5	4	
						3	117	11.7	9.2	4.0	15	
						1-3	197	30.4	17.6	3.5	6.3	2.5
						4	90	26.2	26.9	5.5	15	
						5	72	25.0	30.8	5.2	20	
						6	72	19.2	24.6	5.5	26	
						4-6	78	70.4	82.3	5.4	20.3	8.2
Slimgreen	II	67	300	3.2	82	1	256	2.4	0.8	3.0	-	
						2	160	3.0	1.5	3.0	-	
						3	128	7.3	4.6	3.8	14	
						1-3	181	12.7	6.9	3.3	14	5.9
						4	82	41.0	40.6	4.5	23	
						5	77	21.4	22.6	4.5	21	
						6	67	24.5	29.6	5.0	26	
						4-6	75	86.9	92.8	4.7	23	24.0
Wondergreen	I	64	500	2.0	94	1	384	3.2	0.8	2.0	4	
						2	224	7.5	3.1	2.2	6	
						3	171	8.6	4.6	2.0	10	
						1-3	260	19.3	8.5	2.1	6.7	1.8
						4	98	23.0	21.8	2.2	18	
						5	81	25.6	29.6	3.0	18	
						6	74	32.0	40.6	3.0	19	
						4-6	84	80.6	92.0	2.7	18.3	11.5
Wondergreen	II	67	548	3.3	83	1	256	2.4	0.8	2.0	0	
						2	-	1.2	0.8	-	2	
						3	144	6.0	3.1	3.5	9	
						1-3	200	7.6	4.7	3.2	3.7	1.5
						4	101	22.8	18.7	4.2	14	
						5	80	21.0	21.8	4.2	15	
						6	71	46.9	54.6	4.5	21	
						4-6	84	90.7	95.1	4.3	16.7	11.0

TABLE 2.--Canned Product Evaluation, 1974.

Variety	Harvest	Sieve Size	Percent Seeds	Percent Fiber	U.S.D.A. Grade Factors					
					Liquor	Color	Absence of Defects	Char-acter	Total Score	Grade
Colorna	I	1-3	1.6	.06	10	13	33	37	93	A
	I	4-6	3.0	.15	10	12	33	30*	85	C
	II	4-6	6.2	.23	9	11	33	27*	80	D
Earliwax	I	1-3	5.0	.03	10	15	34	38	97	A
	II	4-6	19.1	.15	10	12	33	31*	86	C
Early Gallatin	I	1-3	0.9	.05	10	14	35	39	98	A
	I	4-6	3.8	.08	10	12	35	38	95	A
	II	4-6	10.9	.12	9	11	32	35*	87	B
GP 467	I	4-6	4.5	.12	10	12	35	36	93	A
	II	4-6	12.3	.19	9	13	33	27*	82	D
GP 68-115	I	4-6	3.9	.13	10	13	33	36	92	A
Slimgreen	I	4-6	8.4	.15	10	15	35	31*	91	C
	II	4-6	11.2	.05	9	12	33	36	90	A
Wondergreen	I	1-3	0.6	.05	10	13	35	39	97	A
	I	4-6	5.9	.10	10	13	35	36	94	A
	II	4-6	7.5	.06	10	13	34	36	93	A

*Limiting rule.

Table 3.--Frozen Product Evaluation, 1974.

Variety	Harvest	Sieve Size	Percent Seeds	U.S.D.A. Grade Factors				
				Color	Absence of Defects	Character	Total Score	Grade
Colorna	I	1-3	1-6	19	39	40	98	A
	I	4-6	4.2	19	38	36	93	A
	II	4-6	5.9	19	38	37	94	A
Earliwax	I	1-3	3.2	16*	38	38	92	B
	II	4-6	15.2	18	37	35*	90	B
Early	I	1-3	1.9	20	40	40	100	A
	II	4-6	11.1	18	38	36	92	A
GP 467	I	1-3	0.4	20	40	40	100	A
	I	4-6	3.7	19	38	38	95	A
	II	4-6	13.0	16*	37	36	89	B
Slimgreen	I	1-3	1-6	18	37	38	93	A
	I	4-6	7.1	17*	37	38	92	B
	II	4-6	13.4	15*	37	35	87	C
Wondergreen	I	1-3	1.2	18	38	39	95	A
	I	4-6	5.7	17*	37	38	92	B

*Limiting rule.

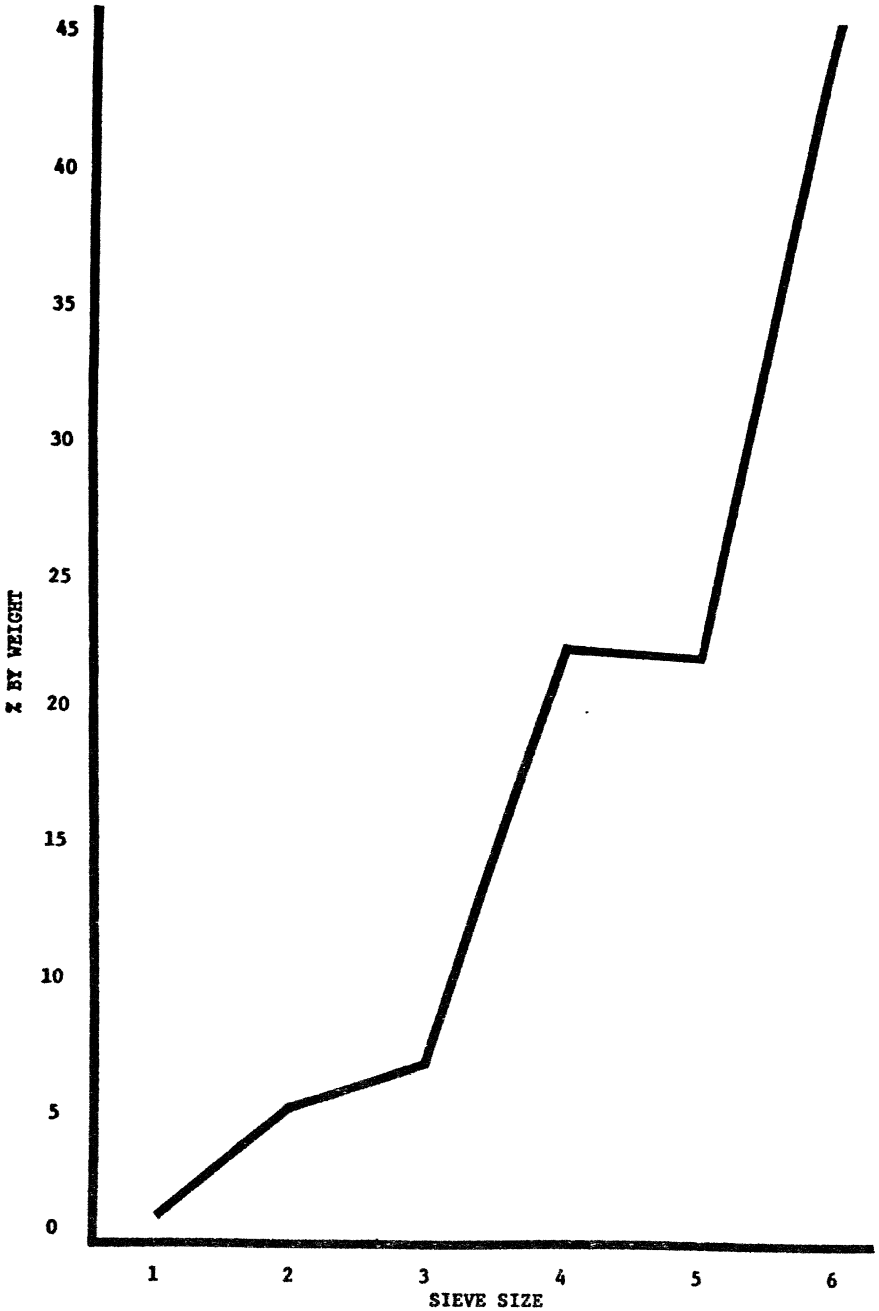

FIG. 1.--Relationship of Percent by Weight to the Sieve Size for the Average of All Cultivars.

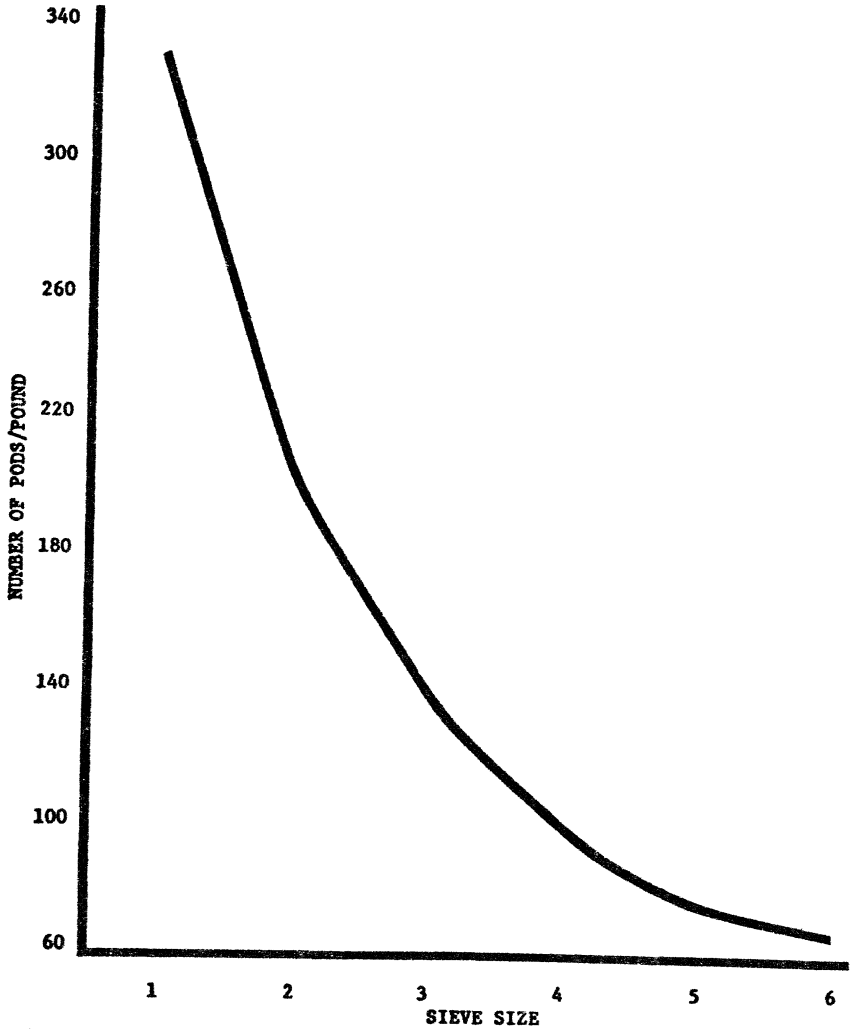

FIG. 2.--Relationship of Number of Pods per Pound to the Sieve Size for the Average of All Cultivars.

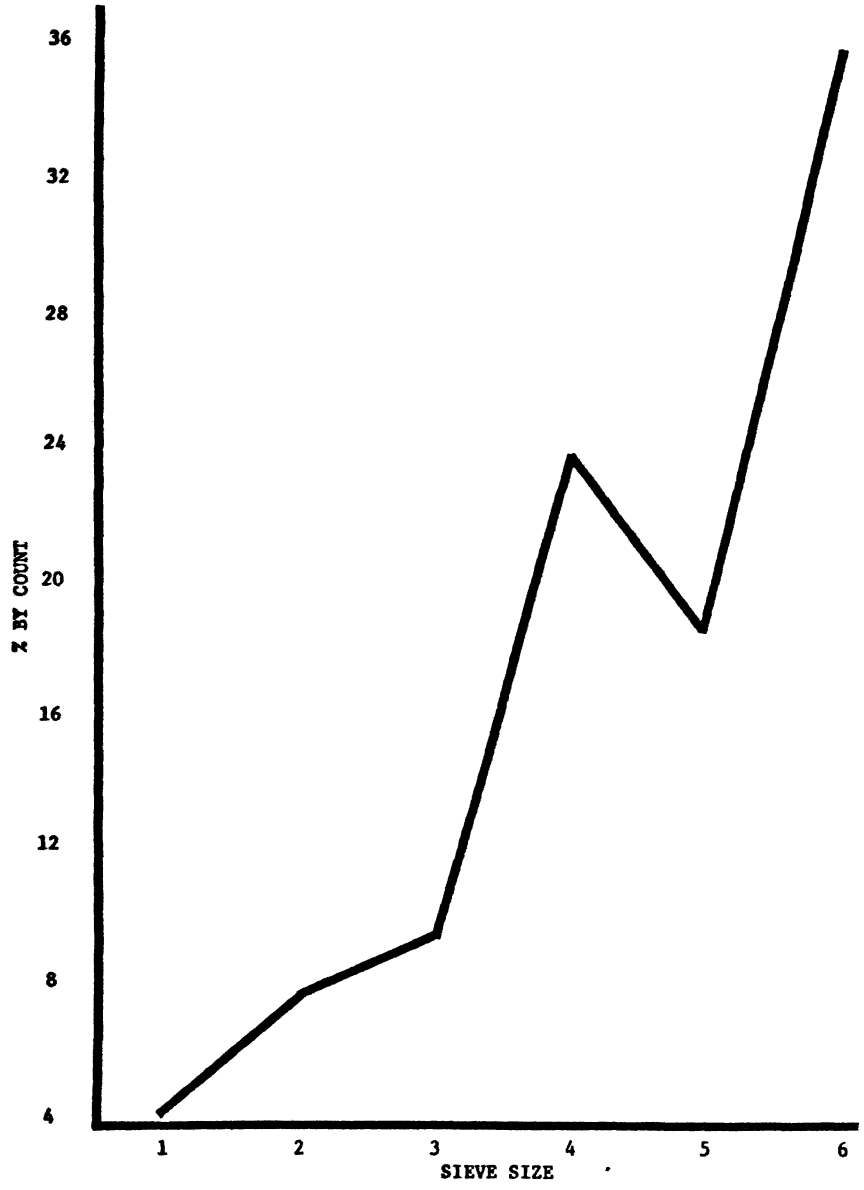

FIG. 3.--Relationship of Percent by Count to the Sieve Size for the Average of All Cultivars.

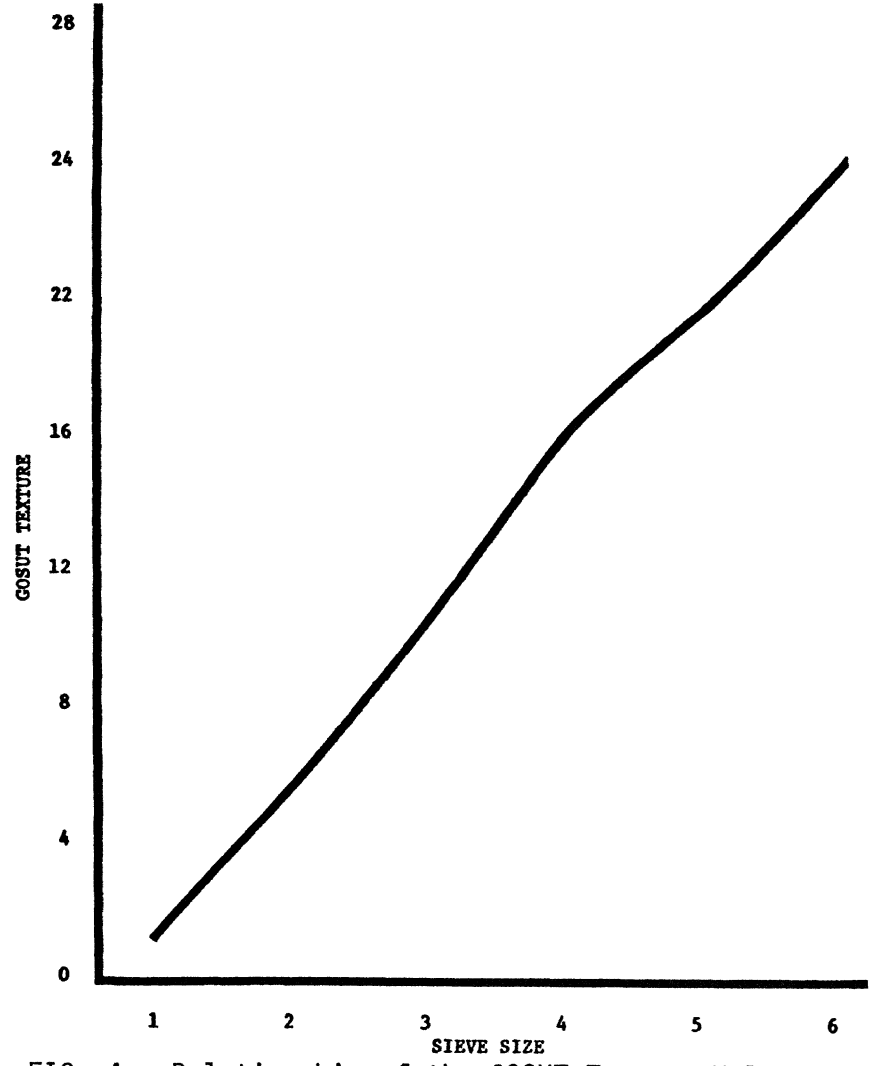

FIG. 4.--Relationship of the GOSUT Texture Values to the Sieve Size for the Average of All Cultivars.

EVALUATING STRAWBERRIES FOR FREEZING

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Strawberries are well suited to preservation by freezing. However, the quality of the product may vary after thawing. One of the most important factors in producing a high quality frozen strawberry is the selection of a suitable cultivar or selection. A good strawberry for freezing should be one that has a bright and uniform red color, delicate and distinctive flavor, and firm texture. In addition, the cultivar should be rich in vitamin C. Strawberries are a good source of vitamin C, with an average serving usually providing the adult minimum daily requirement (30 mg.) of this vitamin.

Since new cultivars and selections are constantly being developed and the need for improved cultivars has increased, a continuing study is underway at the OARDC to ascertain the suitability of promising strawberries for freezing. The results in this report should serve as a guide to growers, processors, and consumers as to those strawberries which will produce a high quality frozen product under Ohio conditions.

Procedure

All strawberry cultivars and selections were grown in the horticultural plots at the OARDC in Wooster. The results of this report summarize the findings of those strawberries evaluated during the period 1972 through 1974.

After the strawberries were washed, drained, and sorted, the caps were removed and each berry was sliced in half. Then 4 lb. (about 8 cups) of sliced berries were mixed with 1 lb. (about 2-1/3 cups) of sugar. The sugared berries were packed and sealed in moisture-vapor containers and placed in -15° F. freezer storage.

After 6 months' storage, the frozen strawberries were thawed, coded, and subjected to a 10-member taste panel for organoleptic evaluation. Each panelist was asked to score the strawberries on a preference scale of 1 through 9 (9 being the most acceptable). The evaluation was repeated twice for each strawberry cultivar and selection.

In addition to the taste panel evaluation, chemical analyses of the thawed berries were made. The following were determined: pH, total acids (as citric), soluble solids, and vitamin C (ascorbic acid).

The selection Md. U.S. 3848 was found to be lowest in pH, 3.24, and highest in total acidity, 0.89% (Table 1). In contrast, Raritan was highest in pH, 3.67, and its total acidity, 0.48%, was lowest of the cultivars and selections studied. Generally, strawberries with high percent total acids tend to be tart. However, this depends on the sweetness (soluble solids or sugar content) of the product.

Since sugars constitute a large percentage of soluble solids in strawberries, the soluble solids content is a good indication of the sugar content of the product. The soluble solids content of the various strawberries (4 + 1 pack) varied from 25.6 to 30.9%, represented by Ark. 5241 and Darrow, respectively.

For the soluble solids-acid ratios, Raritan was found to be highest, 64.2, and Md. U.S. 3848 lowest, 29.3. This ratio is an expression which relates the sweetness

TABLE 1.--Chemical Composition of Frozen Strawberry Cultivars and Selections, 1972-74 Seasons.

Cultivar or Selection	Years	pH	Total Acids Percent	Soluble Solids	Soluble Solids Acid Ratios	Vitamin C mg./100 g.
Ark. 5063	1	3.47	0.60	30.6	51.0	24
Ark. 5241	1	3.53	0.67	25.6	38.2	31
Ark. 5744	1	3.37	0.71	30.3	42.6	45
Badgerglow	1	3.51	0.57	30.1	52.8	38
Cyclone	3	3.49	0.64	27.4	42.8	31
Darrow	3	3.31	0.77	30.9	40.1	39
Delite	2	3.59	0.59	29.8	50.5	31
Earlidawn	1	3.30	0.69	27.0	39.1	43
Guardian	3	3.52	0.63	28.7	45.5	33
Marlate	1	3.57	0.60	27.1	45.2	40
Md. U.S. 3293	1	3.58	0.60	28.0	46.6	30
Md. U.S. 3364	2	3.59	0.59	30.4	51.5	30
Md. U.S. 3498	1	3.48	0.56	27.2	48.6	42
Md. U.S. 3694	2	3.61	0.60	29.9	49.8	32
Md. U.S. 3771	3	3.40	0.71	28.4	40.0	48
Md. U.S. 3848	1	3.24	0.89	26.1	29.3	38
Md. U.S. 3861	1	3.42	0.78	28.2	36.1	49
Md. U.S. 3968	1	3.40	0.76	29.4	38.7	31
Md. U.S. 4089	1	3.40	0.74	30.3	40.9	28
Midway	3	3.55	0.62	27.4	44.2	34
Pocahontas	2	3.44	0.76	25.7	33.8	38
Purdue 11-88	1	3.54	0.66	27.7	41.9	40
Purdue 11-211	1	3.49	0.54	30.0	55.5	40
Raritan	3	3.67	0.48	30.8	64.2	40
Redchief	3	3.34	0.77	29.5	38.3	38
Robinson	3	3.60	0.55	28.4	51.6	50
Stoplight	2	3.61	0.53	28.2	53.2	38
Surecrop	3	3.36	0.83	29.2	35.2	38
Vesper	2	3.66	0.56	28.4	50.7	43
Wis. 655	1	3.33	0.87	26.3	30.2	42
Wis. 699	1	3.32	0.79	29.3	37.1	31
Wis. 6915	1	3.40	0.76	27.9	36.7	32
Wis. 6916	1	3.35	0.77	28.4	36.9	35
Wis. 6917	1	3.38	0.69	30.0	43.5	33

TABLE 2.--Evaluation of Several Strawberry Cultivars and Selections for Freezing, Based on the Quality of the Thawed Product, 1972-74 Seasons.

Cultivar or Selection	Years	Color	Flavor	Texture	Overall Quality*
Ark. 5063	1	6.8	6.6	5.4	18.8
Ark. 5241	1	7.2	6.0	6.2	19.4
Ark. 5744	1	6.3	5.5	5.5	17.3
Badgerglow	1	6.7	6.3	6.7	19.7
Cyclone	3	5.8	6.0	5.4	17.2
Darrow	3	7.2	6.6	6.5	20.3
Delite	2	6.4	5.7	6.5	18.5
Earlidawn	1	7.7	6.8	6.8	21.3
Guardian	3	6.7	6.8	6.7	20.2
Marlate	1	6.8	6.7	6.5	20.0
Md. U.S. 3293	1	6.8	6.5	6.5	19.8
Md. U.S. 3364	2	6.8	6.3	6.1	19.2
Md. U.S. 3498	1	7.0	6.4	6.3	19.7
MD. U.S. 3694	2	7.5	6.3	6.2	20.0
MD. U.S. 3771	3	7.6	7.1	6.7	21.4
Md. U.S. 3848	1	7.9	6.8	7.1	21.8
Md. U.S. 3861	1	6.9	4.9	5.6	17.4
Md. U.S. 3968	1	7.8	8.2	7.4	23.4
Md. U.S. 4089	1	6.7	5.8	6.6	19.1
Midway	3	6.5	6.7	6.6	19.8
Pocahontas	2	7.3	6.7	6.1	20.1
Purdue 11-88	1	6.7	6.4	6.0	19.1
Purdue 11-211	1	6.5	6.0	6.0	18.5
Raritan	3	6.7	6.4	6.1	19.2
Redchief	3	7.0	7.2	6.3	20.5
Robinson	3	5.7	6.1	4.7	16.5
Stoplight	2	7.0	7.2	6.6	20.8
Surecrop	3	7.1	6.6	6.3	20.0
Vesper	2	5.3	5.9	6.0	17.2
Wis. 655	1	7.6	6.4	6.7	20.7
Wis. 699	1	4.5	3.4	3.7	11.6
Wis. 6915	1	7.1	6.2	7.0	20.3
Wis. 6916	1	8.0	6.8	7.4	22.2
Wis. 6917	1	5.4	5.7	5.8	16.9

*Overall quality = sum of the color, flavor, and texture scores.

and tartness of the product. Strawberries with high soluble solids-acid ratios tend to be sweeter than those with lower ratios.

The results of the ascorbic acid determinations showed that frozen strawberries are a good source of vitamin C. The vitamin C content varied from 24 to 50 mg. per 100 grams, represented by Ark. 5063 and Robinson, respectively. The average content for all cultivars and selections was 37 mg. per 100 grams.

The majority of the strawberry cultivars and selections evaluated by the taste panel were acceptable for freezing (Table 2). However, under the conditions of this investigation, a few strawberries tended to have better quality. They are: Md. U.S. 3968, Wis. 6916, Md. U.S. 3848, Md. U.S. 3771, Earlidawn, Stoplight, and Wis. 655.

GRAPES FOR OHIO WINES

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The evaluation of grape varieties and selections for wine and other grape products has been in progress for several years at the OARDC. The grapes used in this study have been grown at the OARDC Southern Branch near Ripley. Since the processing quality of the standard eastern varieties such as Catawba, Delaware, Niagara, and Concord has been established, this investigation is concerned mainly with several varieties relatively untried in southern Ohio.

The Ohio wine industry is currently showing growth and commercial success. This success in Ohio and in the eastern United States is attributed partially to the production of table wines which lack the typical labrusca aroma and flavor. Certainly a few selected varieties and selections, particularly French hybrids, have given the eastern industry an opportunity to produce these "neutral" type wines along with the standard labrusca types.

Since the trend is toward wines lacking labrusca character, the first consideration of this study was to evaluate the wines for labrusca flavor or "foxiness" which is associated with standard American grapes. Other essential points (composition, character, maturity, etc.) were also considered in determining the suitability of grape varieties and selections for winemaking.

The grapes evaluated included the following types: French hybrids, New York hybrids (New York State Agricultural Experiment Station, Geneva, N. Y.), Virginia hybrids (Virginia Polytechnic Institute, Blacksburg, Va.), Canadian hybrids (Horticultural Research Institute of Ontario, Vineland Station, Ont.), Indiana hybrids (E. J. Reeves, Greenfield, Ind.), Munson hybrids, European and American varieties. The evaluation of these varieties and selections for wine was initiated in 1971. However, several of these were not evaluated each year of this study. The results of this report summarize the findings of those grapes evaluated during the period 1971 through 1973.

Procedure

Each variety was harvested at maturity and transported to the OARDC Department of Horticulture in Wooster for wine production. The grapes were stemmed, crushed, and transferred to stainless steel or glass containers. A representative must sample was obtained and analyzed as follows:

1. *pH:* The pH was determined by the glass electrode method (Corning Digital 112 Research pH Meter), using grape juice of each variety.

2. *Total Acids:* A 10-ml. grape juice sample was titrated with a 0.1 normal sodium hydroxide solution to a pH of 8.2. The percent total acids was calculated as tartaric.

3. *Total Soluble Solids:* The soluble solids content was determined by using the Abbe refractometer.

From the soluble solids reading (an indication of sugar content), the amount of sugar needed to bring the original soluble solids content of each variety to 21% was

calculated. The required amount of sugar (sucrose) was added and dissolved in the crushed grapes. Then the musts were treated with 100 p.p.m. of sulfur dioxide in the form of potassium metabisulfite (57.6% sulfur dioxide).

The must from white grapes was immediately pressed, and the juice was ameliorated with 21% sugar syrup to 15% of the resulting volume. Then the juice was transferred to glass carboys and an active yeast culture was added to the juice, 1% by volume, 3 hours after the sulfur dioxide treatment.

For the red, blue, and black grapes, the musts were inoculated with an active yeast culture (1% by volume) 3 hours after the sulfur dioxide treatment. The fermenting crushed grapes were stirred twice daily and were pressed approximately 4 days after the yeast was added to the musts. Then the fermenting juice was ameliorated with 21% sugar syrup to 15% of the resulting volume and transferred to glass carboys.

All carboys were equipped with water seals and were placed in 65° F. storage for fermentation. The fermentations were essentially completed in 4 weeks, and the wines were racked to clean glass carboys at this time. After additional rackings (over a 6-month period), the wines were placed in cold storage (30° F.) for approximately 3 weeks to precipitate the excess tartrates. The wines were racked, bottled, and placed back into 65° F. storage. After 1 month of storage, they were analyzed for composition and quality. The following chemical constituents were determined:

1. *pH*: The pH was determined by the glass electrode method (Corning Digital 112 Research pH Meter), using wine of each variety.

2. *Total Acids*: The wine was titrated with a 0.1 normal sodium hydroxide solution to a pH of 8.2. The percent total acids was calculated as tartaric.

3. *Alcohol:* The alcohol content was determined by using an ebullioscope, Dujordin-Salleron type.

4. *Tannin:* The tannin content was determined by using the standard (Pro) procedure.

5. *Extract:* The extract of the wines was determined by obtaining the density of a dealcoholized sample.

Discussion of Results

The results of the chemical analyses for each of the various grape musts are shown in Table 1. These results represent an average of those years which the grapes were processed into dry table wines. The pH of the must samples varied between 3.00 (S.V. 12375) and 3.84 (Gerwurztraminer). The total acids varied widely, with the New York State hybrid (Geneva, N.Y.) Ontario having the lowest percent, 0.34, and the French hybrid Seibel 8357 having the highest percent, 1.48. The varieties and selections highest in percent soluble solids (sugar) were: Gerwurztraminer (21.2%), White Baco (20.7%), Seibel 10868 (20.5%), and V.P.I. 32 (20.2%).

The analytical data of the composition of the wines are summarized in Table 2. The variety Gerwurztraminer was highest in pH, 3.93, while S.V. 12375 was lowest, 2.90. The results of the total acidity indicated that the wines varied widely, with a range between 0.42% (Munson hybrid "C") to 1.10%, Seibel 8357. A total acidity level of approximately 0.65% is an acceptable value for most table wines.

An overall average for the alcohol and extract contents of the wines was 12.7% and 1.7 (g. per 100 ml.), respectively. The extract content is a measure of the wine's alcohol-free soluble solids and indicates the amount of "body" the wine possesses. The wines highest in tannin content were: Seibel 8357 (303 mg. per 100 ml.) and Vincent (193 mg. per 100 ml.). The tannin content is usually associated with the astringency of the wine.

In addition to the analytical results, Table 2 includes brief statements of the sensory examination of the selected wines. The results of this study and previous investigations including vineyard performance indicate that Baco No. 1, Seibel 9549, Seibel 7053, Seibel 10878, Vincent, Seibel 5279, S.V. 12375, S.V. 5276, and Vidal 256 were best for making non-labrusca type wines. This list is in contrast to those standard American cultivars recommended for making the fruity labrusca type wines. These include Catawba, Delaware, and Niagara.

TABLE 1.--Average Composition of Musts from Various Grape Varieties and Selections, 1971-73 Seasons.

Varieties or Selections	Years	Type*	Color	pH	Total Acids Percent	Soluble Solids Percent
Ahmuer	2	IH	Blue	3.50	0.55	15.3
Bachanoir	2	IH	Blue	3.37	0.66	15.2
Baco No. 1 (Baco Noir)	2	FH	Blue	3.16	1.31	16.9
Bailey	1	M	Blue	3.45	0.52	15.8
Beacon	1	M	Blue	3.54	0.58	12.8
B.S.N. #1	2	M	White	3.33	0.78	14.4
B.S.N. #1 x S.V. 12327	1	IH	White	3.51	0.40	16.3
Cabernet Sauvignon	1	E	Blue	3.22	0.94	17.8
Catawba	3	A	Red	3.11	0.86	17.1
Concord	2	A	Blue	3.37	0.70	14.6
Delaware	2	A	Red	3.40	0.53	19.6
Gerwurztraminer	1	E	Red	3.84	0.73	21.2
Gianina	2	IH	White	3.17	0.83	13.7
Himrod	2	NYH	White	3.26	0.53	17.8
Landot 244 (Landal)	2	FH	Blue	3.38	1.38	18.0
"Mc C" (Munson)	1	M	Red	3.33	0.75	15.5
Niagara	1	A	White	3.52	0.42	12.5
Niawatha	2	IH	White	3.53	0.42	14.8
NI-WA-E 53	2	IH	Blue	3.31	0.86	15.0
Ontario	1	NYH	White	3.58	0.34	16.7
Pinot Noir	1	E	Blue	3.44	0.99	18.2
Ravat 34	3	FH	White	3.33	0.78	17.5
Ravat 51 (Vignoles)	2	FH	White	3.09	1.25	18.2
Ravat 262 (Ravat Noir)	3	FH	Blue	3.01	1.08	18.6
Romulus	1	NYH	White	3.02	0.90	16.3
Seibel 5279 (Aurora)	1	FH	White	3.13	0.84	14.7
Seibel 7053 (Chancellor)	2	FH	Blue	3.21	0.89	12.8
Seibel 8357 (Colobel)	2	FH	Blue	3.09	1.48	17.1
Seibel 9549 (DeChaunac)	3	FH	Blue	3.23	1.00	17.9
Seibel 10868	2	FH	White	3.55	0.82	20.5
Seibel 10878 (Chelois)	2	FH	Blue	3.13	1.31	16.5
Seneca	1	NYH	White	3.17	0.82	18.9
S.V. 5247	2	FH	Blue	3.40	0.78	16.6
S.V. 5276 (Seyval)	3	FH	White	3.20	0.77	18.0
S.V. 12303	2	FH	White	3.12	0.97	15.9

*Grape Types: A = American, CH = Canadian hybrid, E = European, FH = French hybrid, NYH = New York hybrid, M = Munson hybrid, IH = Indiana hybrid, and VH = Virginia hybrid.

TABLE 1. (Continued).--Average Composition of Musts from Various Grape Varieties and Selections, 1971-73 Seasons.

Varieties or Selections	Years	Type*	Color	pH	Total Acids Percent	Soluble Solids Percent
S.V. 12309 (Roucaneuf)	2	FH	White	3.13	0.89	16.7
S.V. 12327	1	FH	Blue	3.45	0.67	16.4
S.V. 12375 (Villard Blanc)	2	FH	White	3.00	1.02	15.0
S.V. 18283 (Garonnet)	3	FH	Blue	3.26	0.89	15.9
S.V. 18315 (Villard Noir)	3	FH	Blue	3.12	1.19	16.4
S.V. 23410 (Valerien)	3	FH	White	3.33	0.58	16.9
Veeport	2	CH	Blue	3.47	0.71	15.0
Vidal 256	2	FH	White	3.07	0.98	16.6
Vincent	2	CH	Blue	3.32	0.73	15.9
V.P.I. 26 (Moored)	3	VH	Red	3.43	0.61	16.3
V.P.I. 30 (Price)	2	VH	Blue	3.36	0.62	19.1
V.P.I. 32	1	VH	Blue	3.44	0.61	20.2
V. 35013	2	CH	Blue	3.13	0.93	17.8
V. 37031	2	CH	White	3.20	0.68	16.2
V. 49063	1	CH	Blue	3.60	0.76	16.4
V. 51011	2	CH	White	3.09	0.93	14.9
V. 51061	2	CH	White	3.03	1.08	17.3
V. 52082	2	CH	Blue	3.24	0.82	13.7
V. 53033	2	CH	Blue	3.16	1.03	15.6
V. 53043	2	CH	Blue	3.45	0.80	16.4
V. 53091	2	CH	Blue	3.11	0.96	15.9
V. 54064	2	CH	Blue	3.33	0.62	13.1
V. 58011	1	CH	White	3.15	0.90	17.9
V. 292718	2	CH	Blue	3.34	0.88	13.1
Washington	1	M	Blue	3.39	0.66	12.8
White Baco	2	FH	White	3.29	1.08	20.7
White Riesling	2	E	White	3.16	0.98	18.8
Zinfandel	1	E	Blue	3.33	1.17	16.8

*Grape Types: A = American, CH = Canadian hybrid, E = European, FH = French hybrid, NYH = New York hybrid, M = Munson hybrid, IH = Indiana hybrid, and VH = Virginia hybrid.

TABLE 2.--Average Composition of Wine from Various Varieties and Selections, 1971-73 Seasons.

Varieties or Selections	Years	pH	Total Acids Percent	Alcohol Percent	Extract g./100 ml.	Tannin mg./100 ml.	Sensory Remarks
Ahmuer	2	3.43	0.51	12.9	1.8	87	Light orange, fruity, slightly labrusca, slightly bitter, fair
Bachanoir	2	3.24	0.68	12.6	1.9	106	Medium red, fruity, labrusca, little tart, good
Baco #1 (Baco Noir)	2	3.34	0.80	12.2	2.1	105	Dark red, rough, tart, pleasant aroma, neutral flavor, good
Bailey	1	3.35	0.61	12.3	1.9	109	Dark red, slightly labrusca, fruity, smooth, good
Beacon	1	3.32	0.67	12.7	2.2	107	Dark red, slightly fruity, smooth, very good
B.S.N. #1	2	3.37	0.52	14.5	2.3	34	Dark yellow, strong labrusca, fruity, little rough, good
B.S.N. #1 x S.V. 12327	1	3.35	0.77	14.1	2.0	30	Medium yellow, vinous, neutral flavor, fair
Cabernet Sauvignon	1	3.51	0.67	11.8	2.0	117	Dark red, distinct aroma, good body, good
Catawba	3	2.98	0.72	13.3	1.8	26	Medium yellow, labrusca, fruity flavor, slightly rough, good
Concord	2	3.19	0.73	11.7	1.8	89	Medium red, strong labrusca, smooth, slightly tart, good
Delaware	2	3.33	0.53	13.0	1.3	27	Medium yellow, slightly labrusca, fruity, good body, very good
Gerwurztraminer	1	3.93	0.51	12.3	2.1	40	Light yellow, distinct aroma, slightly bitter, very good
Gianina	2	3.12	0.78	13.1	1.7	34	Medium yellow, slightly fruity, neutral flavor, tart, fair
Himrod	2	3.10	0.59	13.2	1.4	31	Light yellow, spicy aroma, neutral flavor, fair
Landot 244 (Landal)	2	3.57	0.67	12.7	2.3	132	Dark red, slightly fruity, good body, little rough, very good

TABLE 2 (continued).--Average Composition of Wine from Various Varieties and Selections, 1971-73 Seasons.

Varieties or Selections	Years	pH	Total Acids Percent	Alcohol Percent	Extract g./100 ml.	Tannin mg./100 ml.	Sensory Remarks
"Mc C" (Munson)	1	3.74	0.42	12.0	1.8	72	Light orange, slightly spicy aroma, low acid, fair
Niagara	1	3.27	0.44	11.7	1.1	24	Medium yellow, strong labrusca, low acid, good
Niawatha	2	3.38	0.50	13.8	1.8	36	Medium yellow, labrusca, fruity flavor, low acid, good
NI-WA-E 53	2	3.27	0.72	12.2	1.8	76	Medium red, labrusca, fruity, smooth, fair
Ontario	1	3.28	0.61	13.8	1.3	35	Medium yellow, labrusca, neutral flavor, fair
Pinot noir	1	3.67	0.60	12.0	2.2	100	Light red, H_2S, poor
Ravat 34	3	3.38	0.66	12.4	1.8	29	Light yellow, slightly flowery, distinct aroma, fruity flavor, very good
Ravat 51 (Vignoles)	2	3.16	0.75	13.4	1.6	30	Medium yellow, vinous, good aroma, tart, good
Ravat 262 (Ravat Noir)	3	3.15	0.78	12.1	1.9	116	Dark red, vinous, neutral, smooth, slightly tart, good
Romulus	1	3.11	0.63	13.8	1.6	41	Light yellow, spicy aroma, neutral flavor, thin, fair
S. 5279 (Aurora)	2	3.15	0.73	13.3	1.4	31	Medium yellow, neutral, slightly tart, fruity, good
S. 7053 (Chancellor)	2	3.28	0.71	12.8	1.8	120	Dark red, distinct aroma, slightly fruity, fine flavor, very good
S. 8357 (Colobel)	2	3.14	1.10	11.8	2.8	303	Very dark red, neutral flavor, tart, Teinturier type, fair
S. 9549 (DeChaunac)	3	3.38	0.70	12.0	1.8	157	Dark red, slightly distinct aroma, little tart, fine flavor, very good
S. 10868	2	3.65	0.69	12.6	1.9	36	Light yellow, slightly distinct aroma, slightly fruity, good

TABLE 2 (continued).--Average Composition of Wine from Various Varieties and Selections, 1971-73 Seasons.

Varieties or Selections	Years	pH	Total Acids Percent	Alcohol Percent	Extract g./100 ml.	Tannin mg./100 ml.	Sensory Remarks
S. 10878 (Chelois)	2	3.18	0.94	12.5	1.9	96	Medium red, slightly distinct aroma, tart, good body, good
Seneca	1	3.43	0.66	13.8	1.7	34	Light yellow, mild labrusca, fruity flavor, good
S.V. 5247	2	3.83	0.57	12.2	1.8	88	Light red, vinous, slightly rough, fair
S.V. 5276 (Seyval)	3	3.19	0.74	13.0	1.7	27	Medium yellow, slightly distinct aroma, good body and flavor, very good
S.V. 12303	2	3.07	0.75	14.0	1.7	25	Medium yellow, slightly labrusca, tart, slightly fruity flavor, good
S.V. 12309 (Roucaneuf)	2	3.05	0.81	13.0	1.5	27	Light yellow, vinous, tart, neutral flavor, fair
S.V. 12327	1	3.36	0.76	12.8	2.0	120	Very dark red, vinous, fruity flavor, good body, fair
S.V. 12375 (Villard Blanc)	2	2.90	0.79	12.7	1.4	26	Light yellow, tart, vinous, slightly rough, good
S.V. 18283 (Garonnet)	3	3.21	0.72	12.5	1.6	97	Dark red, vinous, neutral flavor, slightly rough, good
S.V. 18315 (Villard Noir)	3	3.19	0.84	12.1	1.8	141	Very dark red, slightly fruity, tart, smooth, good
S.V. 23410 (Valerien)	3	3.31	0.54	13.8	1.5	29	Medium yellow, vinous, neutral flavor, fair
Veeport	2	3.46	0.62	13.0	1.4	100	Dark red, slightly flowery, smooth, good
Vidal 256	2	2.99	0.73	13.3	1.3	37	Light yellow, fine aroma, little tart, good flavor, very good
Vincent	2	3.45	0.72	12.3	2.4	193	Very dark red, vinous, good body, rough, good
V.P.I. 26 (Moored)	3	3.66	0.49	12.2	1.4	87	Orange, slightly fruity, neutral flavor, low acid, rough, poor

TABLE 2 (continued).--Average Composition of Wine from Various Varieties and Selections, 1971-73 Seasons.

Varieties or Selections	Years	pH	Total Acids Percent	Alcohol Percent	Extract g./100 ml.	Tannin mg./100 ml.	Sensory Remarks
V.P.I. 30 (Price)	2	3.41	0.63	12.0	1.4	80	Red-orange, vinous, neutral flavor, slightly rough, fair
V.P.I. 32	1	3.36	0.59	12.2	1.6	103	Light red, vinous, neutral flavor, flat, fair
V. 35013	2	3.29	0.77	12.6	1.7	123	Medium red, slightly fruity, tart, thin, fair
V. 37031	2	3.23	0.65	12.5	1.3	37	Light yellow, vinous, neutral flavor, good
V. 49063	1	3.62	0.79	12.6	1.1	118	Dark red, herbaceous, tart, thin, neutral, fair
V. 51011	2	3.06	0.71	13.9	1.4	25	Light yellow, slightly fruity, smooth, thin, fair
V. 51061	2	3.14	0.75	13.7	1.4	29	Medium yellow, slightly labrusca, fruity, rough, good
V. 52082	2	3.16	0.72	12.0	1.4	83	Medium red, flowery, rough, thin, poor
V. 53033	2	3.23	0.71	12.0	1.8	156	Dark red, vinous, good body, rough, fair
V. 53043	2	3.54	0.58	12.6	1.4	95	Medium red, poor aroma, flat, thin, poor
V. 53091	2	3.15	0.75	12.5	1.6	99	Light red, vinous, slightly tart, smooth, fair
V. 54064	2	3.30	0.59	13.0	1.5	115	Medium red, vinous, little rough, neutral flavor, fair
V. 58011	1	3.34	0.71	13.6	1.7	38	Light yellow, muscat aroma, rough, thin, fair
V. 292718	2	3.37	0.77	12.3	2.0	174	Dark red, fruity, good body, tart, good
Washington	1	3.45	0.63	12.6	1.4	132	Dark red, vinous, neutral flavor, smooth, very good
White Baco	2	3.52	0.74	11.9	1.9	48	Dark yellow, vinous, neutral flavor, tart, rough, poor
White Riesling	2	3.10	0.75	12.2	1.7	32	Light yellow, slightly distinct aroma, fruity flavor, smooth, good
Zinfandel	1	3.55	0.78	12.7	2.2	132	Medium red, slightly distinct aroma, fruity, good body, good

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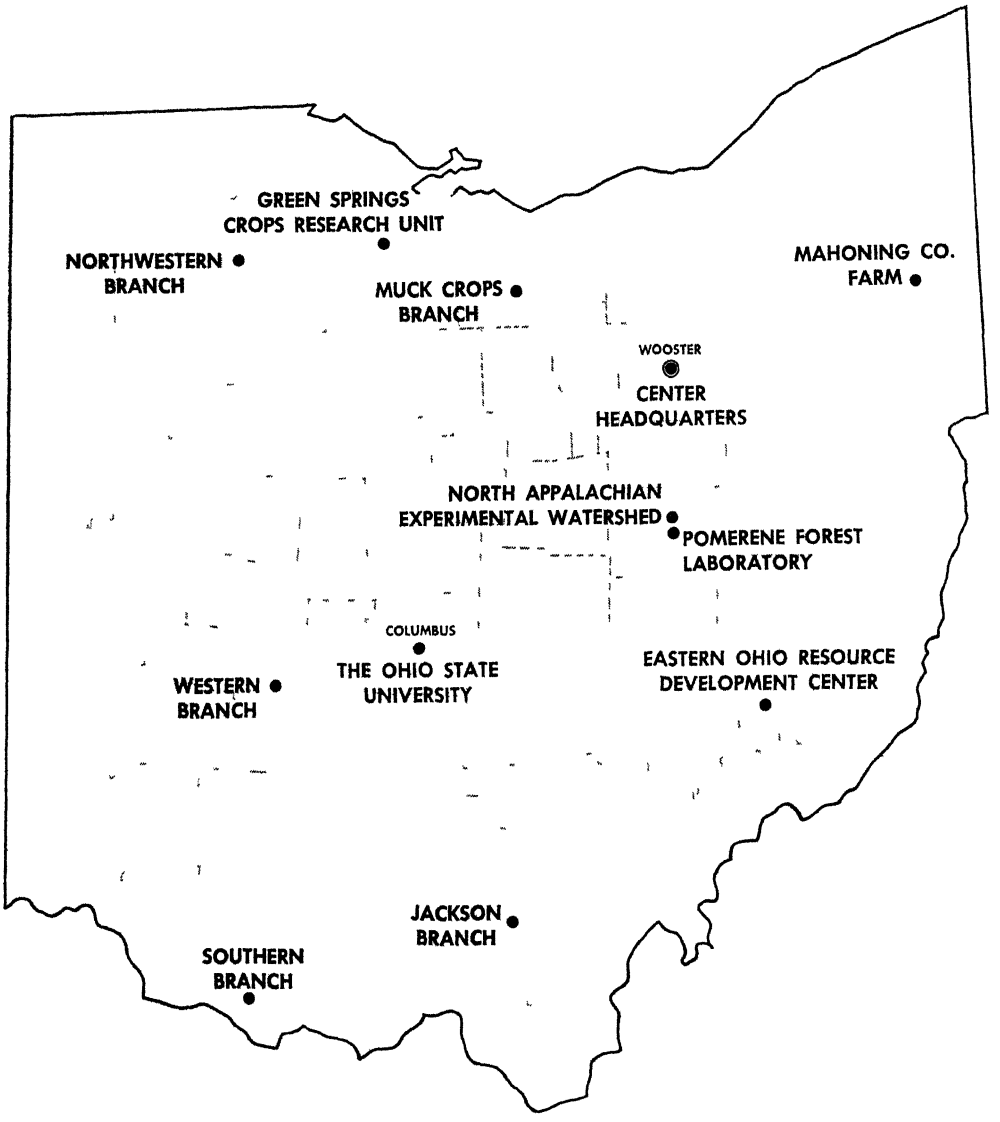

Ohio's major soil types and climatic conditions are represented at the Research Center's 12 locations.

Research is conducted by 15 departments on more than 7000 acres at Center headquarters in Wooster, seven branches, Green Springs Crops Research Unit, Pomerene Forest Laboratory, North Appalachian Experimental Watershed, and The Ohio State University.

Center Headquarters, Wooster, Wayne County: 1953 acres

Eastern Ohio Resource Development Center, Caldwell, Noble County: 2053 acres

Green Springs Crops Research Unit, Green Springs, Sandusky County: 26 acres

Jackson Branch, Jackson, Jackson County: 502 acres

Mahoning County Farm, Canfield: 275 acres

Muck Crops Branch, Willard, Huron County: 15 acres

North Appalachian Experimental Watershed, Coshocton, Coshocton County: 1047 acres (Cooperative with Agricultural Research Service, U. S. Dept. of Agriculture)

Northwestern Branch, Hoytville, Wood County: 247 acres

Pomerene Forest Laboratory, Coshocton County: 227 acres

Southern Branch, Ripley, Brown County: 275 acres

Western Branch, South Charleston, Clark County: 428 acres